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ENGINEERING CORP.

GEOTECHNICAL INVESTIGATION

CITY OF HOUSTON
NORTHWEST WWTP IMPROVEMENTS
5423 MANGUM ROAD
WBS NO. R-000265-0095-3
HOUSTON, TEXAS

Reported to

Parsons, Inc.
Houston, Texas

by

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REPORT NO. G128-12

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EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation performed by Aviles Engineering Corporation (AEC) for the proposed improvements at the City of Houston's (COH) Northwest Wastewater Treatment Plant (WWTP), located at 5423 Mangum Road, in Houston, Texas (Houston/Harris Key Map: 451C and D). Based on out site visits, AEC observed distress at the Blower, Maintenance, and Chemical buildings at the WWTP: (i) distress at the Blower Building includes vertical cracks in the exterior CMU block walls of the building extending from existing grade to the top of the building; (ii) distress at the Maintenance Building includes cracks in the CMU block walls in the maintenance bay, diagonal cracks in the men's locker room and shower, and vertical cracks in the perimeter grade beam at the south side of the building; and (iii) distress at the Chemical Building includes diagonal cracks on the exterior brick finish at the north and south sides of the building, vertical cracks in the interior CMU block walls, and cracks on the chemical tank footings and concrete beams under the catwalk deck.

Our findings and recommendations are summarized below:

- Blower Building: Based on Borings B-1 and B-2, the subsurface conditions at the Blower Building generally consist of approximately 4 to 6 feet of firm to stiff fat clay (CH) and clayey sand (SC) fill material at the ground surface, underlain by approximately 8 to 10 feet of stiff to hard sandy lean clay (CL), followed by approximately 12 to 26 feet of medium dense to very dense silty sand (SM/SP-SM/SP) to the boring termination depths. An approximately 2 foot thick layer of very stiff to hard lean clay (CL) was encountered at a depth of 28 feet in Boring B-1.

  Maintenance Building: Based on Borings B-4 and B-5, the subsurface conditions at the Maintenance Building generally consist of approximately 16 to 18 feet of stiff to hard sandy lean clay (CL) and medium dense silty/clayey sand (SC) fill at the existing ground surface, underlain by approximately 12 to 14 feet of medium dense to very dense silty sand (SM/SP-SM/SP) interbedded with very stiff to hard sandy lean clay (CL) to the boring termination depths.

  Chemical Building: Based on Borings B-8 and B-9, the subsurface conditions at the Chemical Building generally consist of approximately 20 to 24 feet of interbedded soft to hard sandy lean/fat clay (CL/CH) and loose to dense clayey/silty sand (SC/SM) fill materials at the ground surface, underlain by approximately 6 to 12 feet of medium dense to very dense silty sand (SM), followed by approximately 18 feet of stiff to hard fat/lean clay (CH/CL) to the boring termination depths.

- Soil Properties: Details of the soils encountered during drilling are presented on the boring logs. The natural cohesive soils encountered in our borings have Liquid Limits (LL) ranging from 35 to 64 and Plasticity Indices (PI) ranging from 20 to 40. In addition, the cohesive fill soils encountered have LL ranging from 25 to 51 and PI ranging from 18 to 35. This indicates that the cohesive soils have low to high expansive potential. The cohesive soils encountered are classified as "CL" and "CH" type soils and the granular soils are classified as "SM", "SC", "SP-SM", and "SP" type soils in accordance with ASTM D 2487.

EXECUTIVE SUMMARY (Cont.)

- Groundwater Conditions: Groundwater was encountered at a depth of 23 to 25 feet below grade during drilling in Borings B-1 and B-9. Ground water was not encountered in the remaining borings during drilling. After completion of drilling, the borings remained open so that 24 hour groundwater readings could be obtained. For borings that remained dry after the 24 hour groundwater readings, AEC has conservatively assumed that the groundwater level is at the depth equal to the cave in depth of the boring. The 24-hour groundwater depths varied from 6.7 to 26.8 feet below the existing ground surface. Detailed groundwater levels are summarized in Table 3.

- Hazardous Materials: We did not detect any visual evidence or odor indicating the presence of hazardous materials in the soil samples. However, AEC notes that the presence of potential hazardous material within the project area cannot be discounted based upon the very small and limited number of samples taken.

- Blower Building: Evaluation of the Blower Building foundations is presented in Section 5.1 of this report. Based on our analysis, the foundation pressure of the existing drilled footing that supports Column A-1 at the northwest corner of the Blower Building exceeds the allowable bearing capacity of the subsurface soils encountered in Boring B-1, which has resulted in large differential settlement. However, AEC understands that remediation of the Blower Building foundations is not currently under consideration.

- Maintenance Building: Evaluation of the Maintenance Building foundations is presented in Section 5.2 of this report. AEC notes that a thick layer of very soft to firm sandy clay fill material (from manhole and sanitary sewer pipe backfill) was encountered in Fugro Boring B-1. Based on our analysis, the foundation pressure of the existing drilled footing that supports Columns H-5A, H-6, and J-5A at the east wing of the Maintenance Building exceeds the allowable bearing capacity of the subsurface soils encountered in Fugro Boring B-1 and AEC Boring B-4, which has resulted in large differential settlement. AEC recommends that the east wing of the Maintenance Building be underpinned with either drilled-and-underreamed footings or straight-sided drilled shafts.

- Chemical Building: Evaluation of the Chemical Building foundations is presented in Section 5.3 of this report. AEC notes that the Chemical Building is supported on a mat foundation that was constructed on thick highly variable fill material (backfill from the adjacent Chlorine Contact Basins). In addition, the loading of the mat foundation slab is highly variable, with chemical tanks at the north end of the building, sample room and pump/electrical equipment room at the center, and a covered walkway/pipe trenches at the south end of the building. The differential loading of the mat foundation and the thick highly variable fill material has resulted in large differential settlement of the Chemical Building. AEC recommends using compaction grout, or jet grout (or other appropriate methods) to improve the foundation soils.

- This Executive Summary provides an overview of the geotechnical investigation and should not be used without the full text of this report.

GEOTECHNICAL INVESTIGATION

CITY OF HOUSTON
NORTHWEST WWTP IMPROVEMENTS
5423 MANGUM ROAD
WBS NO. R-000265-0095-3
HOUSTON, TEXAS

1.0 INTRODUCTION

1.1 Project Description

This report presents the results of a geotechnical investigation performed by Aviles Engineering Corporation (AEC) for the proposed improvements at the City of Houston's (COH) Northwest Wastewater Treatment Plant (WWTP), located at 5423 Mangum Road, in Houston, Texas (Houston/Harris Key Map: 451C and D). A vicinity map is presented on Plate A-1 in Appendix A. Based on out site visits, AEC observed distress at the Blower, Maintenance, and Chemical buildings at the WWTP: (i) distress at the Blower Building includes vertical cracks in the exterior CMU block walls of the building extending from existing grade to the top of the building; (ii) distress at the Maintenance Building includes cracks in the CMU block walls in the maintenance bay, diagonal cracks in the men's locker room and shower, and vertical cracks in the perimeter grade beam at the south side of the building; and (iii) distress at the Chemical Building includes diagonal cracks on the exterior brick finish at the north and south sides of the building, vertical cracks in the interior CMU block walls, and cracks on the chemical tank footings and concrete beams under the catwalk deck.

1.2 Authorization

This investigation was authorized via Subcontract Agreement between AEC and Parsons Water and Infrastructure by Mr. Rick Miller, Senior Procurement Manager of Parsons, Inc. based upon AEC Proposal No. G2011-09-16R2, dated June 7, 2012.

1.3 Purpose and Scope

The purpose of the investigation includes evaluation of existing subsurface and groundwater conditions to determine potential reasons for distress to the buildings and develop geotechnical engineering recommendations for remediation measures. The scope of this geotechnical investigation is summarized below:

1. Drilling and sampling six soil borings varying in depth from 30 to 50 feet below existing grade;
2. Performing soil laboratory testing on selected soil samples;
3. Engineering analysis of subsurface and groundwater conditions to determine potential causes of building distress;
4. Recommendations for building distress remediation methods.

2.0 SUBSURFACE EXPLORATION

Based on our original proposal, subsurface conditions at the site were to be investigated by performing a total of ten borings ranging in depth from 15 to 40 feet; six borings were to be located outside the existing Blower (Borings B-1 through B-3), Maintenance (Borings B-4 and B-5), and Chemical buildings (Boring B-8) and four borings were to be located within the Maintenance (Borings B-6 and B-7) and Chemical Buildings (Borings B-9 and B-10). However, Borings B-3 and B-6 were deleted prior to drilling (as requested by Parsons), and Borings B-7 and B-10 were cancelled in the field, due to portable drill rig access issues in Boring B-7 and the presence of a lower-level 2 foot thick concrete mat foundation at Boring B-10. Boring B-4 was relocated from the west side of the Maintenance Building to the east side due to obstructions, while Boring B-9 was relocated from the building interior to the outside of the southeast corner of the building and deepened to 50 feet below grade.

Subsurface conditions at the site were investigated by drilling six borings to depths ranging from 30 to 50 feet below existing grade. The total drilling footage was 210 feet. After completion of drilling, the borings were surveyed. Boring survey data is included on the representative boring logs. The boring locations are shown on the Boring Location Plan presented on Plate A-2, in Appendix A. A summary of borings performed for this project are presented on Table 1.

Table 1. Summary of Borings

Boring No.	Boring Depth (ft)	Boring Purpose
B-1	40	Blower Building
B-2	30	Blower Building
B-3[(a)]	--	--
B-4	30	Maintenance Building
B-5	30	Maintenance Building
B-6[(a)]	--	--
B-7[(a)]	--	--
B-8	30	Chemical Building
B-9	50	Chemical Building

Boring No.	Boring Depth (ft)	Boring Purpose
B-10[a]	--	--

Notes: (a) Boring deleted.

The borings were drilled using a truck-mounted drill rig; existing concrete pavement at Borings B-1, B-4, and B-8 was cut with a core barrel prior to drilling. Borings were performed initially by dry auger method, then using wet rotary method once the borings caved in or saturated granular soils were encountered. Undisturbed samples of cohesive soils were obtained from the borings by pushing 3-inch diameter thin-wall, seamless steel Shelby tube samplers in accordance with ASTM D 1587. Granular soils were sampled with a 2-inch split-barrel sampler in accordance with ASTM D 1586. Standard Penetration Test resistance (N) values were recorded for the granular soils as "Blows per Foot" and are shown on the boring logs. Strength of the cohesive soils was estimated in the field using a hand penetrometer. The undisturbed samples of cohesive soils were extruded mechanically from the core barrels in the field and wrapped in aluminum foil; all samples were sealed in plastic bags to reduce moisture loss and disturbance. The samples were then placed in core boxes and transported to the AEC laboratory for testing and further study. After completion of drilling, the borings were left open for a period of approximately 24 hours so that an additional groundwater reading could be taken. The borings were then grouted with cement-bentonite and the pavement surface patched with either lean concrete or asphalt, depending on the existing pavement surface. Details of the soils encountered in the borings are presented on Plates A-3 through A-11, in Appendix A.

3.0 LABORATORY TESTING

Soil laboratory testing was performed by AEC personnel. Samples from the borings were examined and classified in the laboratory by a technician under supervision of a geotechnical engineer. Laboratory tests were performed on selected soil samples in order to evaluate the engineering properties of the foundation soils in accordance with applicable ASTM Standards. Atterberg limits, moisture contents, percent passing a No. 200 sieve, mechanical sieve analysis, and dry unit weight tests were performed on representative samples to establish the index properties and confirm field classification of the subsurface soils. Strength properties of cohesive soils were estimated by means of unconfined compression (UC) and Unconsolidated-Undrained (UU) triaxial tests performed on undisturbed samples. The test results are presented on their representative boring logs. A key to the boring logs, classification of soils for engineering purposes, terms used on boring logs, and reference ASTM Standards for laboratory testing are presented on Plates A-12 through A-15, in Appendix A. Sieve analysis results are presented on Plates A-16 and A-17, in Appendix A.

Five one-dimensional consolidation tests were performed on selected soil samples to evaluate the general compressibility characteristics of the clay soils below the existing building foundations. The initial void ratio, compression index, recompession index, preconsolidation pressure, and estimated overconsolidation ratio (OCR) for the consolidation tests are summarized in Table 2. The result of the consolidation tests are presented on Plates A-18 through A-22, in Appendix A.

Table 2. Summary of Consolidation Test Results

Sample ID and Description	e_0	C_c	C_r	p_c (tsf)	OCR
B-1, 10'-12', Sandy Lean Clay (CL)	0.5225	0.1129	0.0130	2.5	3.6
B-4, 14'-16', Fill: Sandy Lean Clay (CL)	0.4362	0.0869	0.0080	2.8	3.1
B-8, 8'-10', Fill: Clayey Sand (SC)	0.4803	0.0830	0.0089	1.4	2.9
B-9, 16'-18', Fill: Lean Clay (CL)	0.5951	0.1384	0.0148	1.1	1.5
B-9, 43'-45', Fat Clay (CH)	0.6978	0.2025	0.0373	6.9	4.5

Note: (1) e_0 = initial void ratio;
(2) C_c = compression ratio;
(3) C_r = recompession ratio, which is derived from the recompession curve within the stress range from 1 to 4 ksf;
(4) p_c = preconsolidation pressure; and
(5) OCR = overconsolidation ratio.

4.0 SITE CONDITIONS

On our July 10, 2012 site visit, AEC observed numerous signs of distress to the existing Blower, Maintenance, and Chemical Buildings.

Blower Building: The existing blower building is a two story CMU block wall building. AEC observed vertical cracks (ranging from 1 to 6 millimeters wide) extending from existing grade to the top of the CMU block wall at the northwest corner, middle section of the south wall, and southwest corner of the building.

Administration/Maintenance Building: The Administration Building is a two story structure with CMU block walls and an exterior brick finish and the Maintenance Building is a one-and-a-half story structure with CMU block walls and an exterior brick finish. The buildings are connected to each other by a walkway and are located on a built-up area that is approximately 6 feet higher than surrounding grade. AEC did not observe any significant distress to the Administration Building at the time of our site visits, but was informed by onsite personnel that distress to the Administration Building, walkway area, and front of the Maintenance Building had previously been repaired. Drawings from 1997 indicate that the front (i.e. southern wall) of the Maintenance Building had been underpinned with additional straight sided drilled shafts.

At the time of our site visits, AEC observed cracks in the CMU block walls in the maintenance bay, diagonal cracks (ranging from 10 to 20 millimeters wide) in the men's locker room and shower (some of which showed signs of previous repair attempts), and vertical cracks/concrete spalling in the joint between the perimeter grade beam and retaining wall at the southeast corner of the building.

Chemical Building: The Chemical Building is CMU block building with exterior brick finish; the north portion of the building is a covered area that houses 4 chemical tanks in a recessed pit area. We observed numerous cracks on the suspended concrete walkways between the chemical tanks, and large diagonal cracks (greater than 25 millimeters wide) on the exterior brick finish on the north and south sides of the building. In the interior of the building, we observed numerous large diagonal cracks on the CMU block walls inside the pump, chemical, and electrical rooms. There are numerous cracks on the chemical tank footings and concrete beams under the walking deck located west side of the tank farm. We also observed a horizontal crack in the pavement core recovered from Boring B-8.

4.1 Subsurface Conditions

Soil strata encountered in our borings are summarized below.

Boring	Depth	Description of Stratum
B-1	0' - 0.6'	Pavement: 7" concrete
	0.6' - 0.8'	Base: 3" sand and gravel
	0.8' - 4'	Fill: firm to stiff, Fat Clay w/Sand (CH)
	4' - 14'	Stiff to hard, Sandy Lean Clay (CL)
	14' - 18'	Medium dense to dense, Silty Sand (SM)
	18' - 27'	Medium dense, Poorly Graded Sand w/Silt (SP-SM)
	27' - 40'	Medium dense to very dense, Poorly Graded Sand (SP)
B-2	0' - 0.7'	Pavement: 8" asphalt
	0.7' - 0.9'	Base: 3" sand, shell, and gravel, with clay partings
	0.9' - 4'	Fill: Clayey Sand (SC)
	4' - 6'	Fill: very stiff, Lean Clay (CL), with silty sand pockets
	6' - 12'	Very stiff to hard, Lean Clay w/Sand (CL)
	12' - 16'	Very stiff, Sandy Lean Clay (CL)
	16' - 22'	Medium dense, Silty Sand (SM)
	22' - 28'	Medium dense, Poorly Graded Sand w/Silt (SP-SM)
	28' - 30'	Very stiff to hard, Lean Clay (CL), with silty sand pockets

Boring	Depth	Description of Stratum
B-3 (deleted)		
B-4	0' - 0.6'	Pavement: 7" concrete
	0.6' - 0.8'	Base: 3" sand and gravel
	0.8' - 18'	Fill: stiff to hard, Sandy Lean Clay (CL), with fat clay pockets
	18' - 22'	Medium dense, Silty Sand (SM)
	22' - 25'	Very stiff, Lean Clay (CL), with silty sand pockets
	25' - 30'	Medium dense, Poorly Graded Sand (SP)
B-5	0' - 0.8'	Pavement: 9" asphalt
	0.8' - 1'	Base: 3" sand and gravel
	1' - 4'	Fill: Clayey Sand (SC), with silty sand seams
	4' - 14'	Possible Fill: medium dense, Silty Sand (SM)
	14’ - 16’	Possible Fill: Clayey Sand (SC)
	16' - 18'	Hard, Sandy Lean Clay (CL)
	18' - 27'	Medium dense, Poorly Graded Sand w/Silt (SP-SM)
	27' - 30'	Very dense, Silty Sand (SM), with fat clay seams
B-6 (deleted)		
B-7 (deleted)		
B-8	0' - 0.7'	Pavement: 8.5" concrete
	0.7' - 0.8'	Base: 3" sand and gravel
	0.8' - 4'	Fill: Clayey Sand (SC), with fat clay and silty sand pockets
	4' - 6'	Fill: Silty Sand (SM), with lean clay pockets
	6' - 12'	Fill: Clayey Sand (SC), with fat clay and silty sand pockets
	12' - 20'	Fill: stiff to hard, Sandy Lean Clay (CL), with fat clay and silty sand pockets
	20' - 24'	Fill: Clayey Sand (SC), with fat clay pockets
	24' - 30'	Medium dense, Silty Sand (SM)
B-9	0' - 2'	Fill: very stiff, Sandy Lean Clay (CL), with gravel and silty sand layers
	2' - 6'	Fill: loose to dense, Clayey Sand (SC)
	6' - 12'	Fill: medium dense to dense, Silty Sand (SM)
	12' - 14'	Fill: very stiff, Sandy Fat Clay (CH)
	14' - 18'	Fill: soft to stiff, Lean Clay (CL), with silty sand seams
	18' - 20'	Fill: Silty Sand (SM), with clayey sand pockets
	20' - 32'	Medium dense to very dense, Silty Sand (SM)
	32' - 36'	Hard, Fat Clay (CH), with silty sand seams
	36' - 41'	Stiff to very stiff, Sandy Lean Clay (CL), with silt seams, fat clay pockets, and siltstone fragments
	41' - 50'	Very stiff, Fat Clay (CH), with slickensides
B-10 (deleted)		

Details of the soils encountered during drilling are presented on the boring logs. The natural cohesive soils encountered in our borings have Liquid Limits (LL) ranging from 35 to 64 and Plasticity Indices (PI) ranging from 20 to 40. In addition, the cohesive fill soils encountered have LL ranging from 25 to 51 and PI ranging from 18 to 35. This indicates that the cohesive soils have low to high expansive potential. The cohesive soils encountered are classified as "CL" and "CH" type soils and the granular soils are classified as "SM", "SC", "SP-SM", and "SP" type soils in accordance with ASTM D 2487. "CH" soils can undergo significant volume changes due to seasonal changes in moisture contents. "CL" soils with lower LL (less than 40) and PI (less than 20) generally do not undergo significant volume changes with changes in moisture content. However, "CL" soils with LL approaching 50 and PI greater than 20 essentially behave as "CH" soils and could undergo significant volume changes.

Groundwater Conditions: Groundwater was encountered at a depth of 23 to 25 feet below grade during drilling in Borings B-1 and B-9. Ground water was not encountered in the remaining borings during drilling. After completion of drilling, the borings remained open so that 24 hour groundwater readings could be obtained. For borings that remained dry after the 24 hour groundwater readings, AEC has conservatively assumed that the groundwater level is at the depth equal to the cave in depth of the boring. Detailed groundwater levels are summarized in Table 3.

Table 3. Groundwater Depths below Existing Ground Surface

Boring No.	Date Drilled	Boring Depth (ft)	Groundwater Depth Encountered during Drilling (ft)	Groundwater Depth after 24 Hours (ft)
B-1	7/18/12	40	25	26.8 (cave in)
B-2	7/18/12	30	Dry	22.2 (cave in)
B-3	deleted			
B-4	7/18/12	30	Dry	26.2 (cave in)
B-5	7/18/12	30	Dry	21.8 (cave in)
B-6	deleted			
B-7	deleted			
B-8	7/18/12	30	Dry	6.7 6.8 (cave in)
B-9	7/20/12	50	23	7.0 7.2 (cave in)
B-10	deleted			

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The information in this report summarizes conditions found on the dates the borings were drilled. However, it should be noted that our ground water observations are short term; ground water depths and subsurface soil moisture contents will vary with environmental variations such as frequency and magnitude of rainfall and the time of year when construction is in progress.

4.2 Hazardous Materials

We did not detect any visual evidence or odor indicating the presence of hazardous materials in the soil samples. However, AEC notes that the presence of potential hazardous material within the project area cannot be discounted based upon the very small and limited number of samples taken.

4.3 Subsurface Variations

It should be emphasized that: (i) at any given time, ground water depths can vary from location to location, and (ii) at any given location, ground water depths can change with time. Ground water depths will vary with seasonal rainfall and other climatic/environmental events. Subsurface conditions may vary between borings.

Clay soils in the Houston area typically have secondary features such as slickensides and contain sand/silt seams/lenses/layers/pockets. It should be noted that the information in the boring logs are based on 3-inch diameter soil samples which were generally obtained at intervals of 2 feet in the top 20 feet of the borings and at intervals of 5 feet thereafter to the boring termination depths. A detailed description of the soil secondary features may not have been obtained due to the small sample size and sampling interval between the samples. Therefore, while a boring log shows some soil secondary features, it should not be assumed that the features are absent where not indicated on the boring logs.

5.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

Based on out site visits, AEC observed distress at the Blower, Maintenance, and Chemical buildings at the WWTP: (i) distress at the Blower Building includes vertical cracks in the exterior CMU block walls of the building extending from existing grade to the top of the building; (ii) distress at the Maintenance Building includes cracks in the CMU block walls in the maintenance bay, diagonal cracks in the men's locker room and shower, and vertical cracks in the perimeter grade beam at the south side of the building; and (iii) distress at the Chemical Building includes diagonal cracks on the exterior brick finish at the north and south sides of the building, vertical cracks in the interior CMU block walls, and cracks on the chemical tank footings and concrete beams under the catwalk deck.

Parsons provided AEC with several sets of existing drawings for the WWTP. Relevant drawing sets from the WWTP include:

- "Proposed Expansion of Northwest District Sewage Treatment Plant", prepared by Dannenbaum Engineering Corporation, dated April 1976
- "Northwest District Sewage Treatment Plant, Proposed 6 MGD Expansion" (as-built), prepared by Chas R. Haile Associates, Inc., dated January 1983 to March 1984, revised April 1987
- "Improvements to the Northwest Wastewater Treatment Plant", (as-built), prepared by Malcolm Pirnie, dated March 1988
- "Northwest Wastewater Treatment Plant, Control & Maintenance Building" (as-built), prepared by Malcolm Pirnie, dated January 10, 1989
- "Administration and Maintenance Building Modifications, Northwest Wastewater Treatment Plant", prepared by Ratnala & Bahl, Inc., February 1997

In addition, Parsons provided AEC with a draft geotechnical report "Geotechnical Evaluation, Sinkhole and Building Distress at Northwest Wastewater Treatment Plant", dated December 1993, that was prepared by Bernard Johnson Incorporated (BJI)/Fugro-McClelland (Southwest), Inc. for remediation of building distress at the Administration/Maintenance Building. Relevant information from BJI/Fugro's report (including Fugro Boring B-1, boring plan, etc.) is presented on Plates B-1 through B-3, in Appendix B for reference.

KIT Professionals performed an elevation survey for the Blower, Maintenance, and Chemical Buildings, which are included on Plates B-4 through B-7, in Appendix B for reference. Column loads for the buildings were provided to AEC by KIT Professionals, Inc. via email and are included in Plate B-8, in Appendix B, for reference.

5.1 Blower Building

According to drawings provided by Parsons, the west portion of the Blower Building was initially constructed in 1976 and the east portion was constructed in 1987. Both portions of the Blower Building are supported on belled footings, typically with a 30 inch shaft diameter and 78 inch bell diameter. The bell footings are founded at an elevation of 76.0 feet above Mean Sea Level (MSL), i.e. approximately 11 feet below finished grade. According to KIT Professionals, the foundation loads for the Blower Building are 163 kips for sustained dead load and 12 kips for live loads.

5.1.1 Allowable Bearing Pressures for Existing Footings

Based on the subsurface soil conditions encountered in Borings B-1 and B-2, we calculated net allowable bearing pressures (with Factors of Safety of 3 and 2, for dead loads and total loads, respectively) for the Blower Building footings. Allowable footing pressures are presented in Table 4.

Table 4. Allowable Bearing Pressures for Selected Bell Footings

Footing ID	Footing Size and Depth	Existing Footing Pressure (psf)		Allowable Bearing Pressure (psf)	
		Dead Load	Total Load	Dead Load	Total Load
A-1 (Boring B-1)	6.5' Dia., 11' deep	4,912	5,274	3,093	4,639
B-4 (Boring B-2)	6.5' Dia., 11' deep	4,912	5,274	4,957	7,436

As can be seen from Table 4, the existing footing pressure at Column A-1 is greater than the allowable bearing pressure, which may be the cause of overlarge differential settlement and cracks on the CMU walls.

5.1.2 Settlement Analyses for Existing Footing

Based on Boring B-1, AEC performed settlement analysis on Column A-1. In the settlement analyses, we considered that the ground water table is located at a depth of at least 26 feet below existing grade based on our short-term ground water readings. The estimated settlements for the Column A-1 footing is presented in Table 5.

Table 5. Estimated Consolidation Settlements for Selected Bell Footings

Footing ID	Footing Size and Depth	S (in)	S_s (in)	S_c (in)	δ (in)
A-1 (Boring B-1)	6.5' Dia., 11' deep	1.22	0.95	0.06	0.21

Notes: (1) $S = S_s + S_c + \delta$, estimated total settlement; S_s = estimated consolidation settlement for sand; S_c = estimated consolidation settlement for clay; δ = estimated immediate (elastic) settlement.

The estimated settlements in Table 5 reasonably compare with the cracks we observed (1 to 6 millimeters) on the northwest corner of the Blower Building. It is AEC's opinion that insufficient allowable bearing capacity contributed to the large settlement/differential settlement which has occurred at the Blower Building.

Time Rates of Consolidation Settlements: Given the construction dates of the Blower Building (1976 and 1987), and based on the footing depth of approximately 11 feet indicated in the drawings, and since sandy soils was encountered at a depth of 14 to 16 feet in Borings B-1 and B-2, it is AEC's opinion that the long-term consolidation settlement of the Blower Building footings should have already been completed.

5.1.3 Foundation Remediation

Based on our conference calls with KIT Professionals, AEC understands that no major remediation action will be performed for the Blower Building at this time.

5.2 Maintenance Building

Administration/Maintenance Building: According to drawings provided by Parsons, the Administration and Maintenance Buildings were constructed in 1988. The Maintenance Building is supported on drilled footings with shaft diameters that range from 12 to 26 inches and bell diameters that range from 24 inches to 78 inches, founded at approximately 11 feet below finished grade. The finished floor elevation (FFE) of the building is at an elevation of 90.17 feet above MSL. Column loads provided by KIT Professionals are presented on Table 6 below.

Table 6. Column Loads and Existing Footing Pressures of Selected Bell Footings

Footing ID	Footing Size and Depth	Column Load (kips)		Existing Footing Pressure (psf)	
		Dead Load	Live Load	Dead Load	Total Load
H-5A (Fugro B-1)	2.5' Dia., 11 deep	22	8	4,482	6,112
H-6 (Fugro B-1)	5' Dia., 11 deep	55	10	2,801	3,310
J-5A (Fugro B-1)	4.5' Dia., 11 deep	49	6	3,081	3,458

According to original drawings from Malcolm Pirnie (dated 1989), an existing sanitary sewer manhole with 6 inch and 18 inch sanitary sewer pipes that were located at the center of the Maintenance Building were abandoned. In addition, two sanitary sewer manholes (and associated 8 inch diameter drain pipes) were installed within the covered walkway area between the Maintenance and Administration Buildings. The invert depth of the two manholes is at 61.98 and 66.22 feet above MSL (i.e. approximately 29 feet below final grade), respectively.

Additional foundations were installed along the southern exterior wall at the east wing the Maintenance Building in 1997. According to the provided drawings, 35 foot long battered pairs of 24 to 30 inch diameter drilled shafts were installed along the southern perimeter of the Maintenance Building. However, no foundation remediation was performed under the interior walls at the men's locker room and shower.

5.2.1 Allowable Bearing Pressures for Existing Footings

Based on the subsurface soil conditions encountered in Fugro Boring B-1 (AEC Boring B-4 was also used as a reference), we calculated net allowable bearing pressures (with Factors of Safety of 3 and 2, for dead loads and total loads, respectively) for the Maintenance Building footings. Allowable bearing pressures are presented in Table 7.

Table 7. Allowable Bearing Pressures for Selected Bell Footings

Footing ID	Footing Size and Depth	Allowable Bearing Pressure (psf)	
		Dead Load	Total Load
H-5A (Fugro B-1)	2.5' Dia., 11 deep	1,813	2,719
H-6 (Fugro B-1)	5' Dia., 11 deep	1,651	2,477
J-5A (Fugro B-1)	4.5' Dia., 11 deep	1,701	2,551

For the interior walls within the men's locker room and shower at the east wing of the Maintenance Building, the cracks appear to be caused by overlarge differential settlement since thick, weak soils were encountered in Fugro-McClelland's Boring B-1 and AEC Boring B-4. In particular, approximately 23 feet of very soft to firm sandy clay fill (manhole and sanitary sewer backfill) was encountered in Fugro Boring B-1.

As can be seen from Tables 6 and 7, the existing footing pressures at Columns H-5A, H-6, and J-5A are greater than the allowable bearing pressures. It is AEC's opinion that insufficient allowable bearing capacity contributed to the overlarge differential settlement and cracks on the interior CMU wall in the Maintenance Building.

5.2.2 Settlement Analyses for Existing Footing

Based on Fugro Boring B-1 and AEC Boring B-4, AEC performed settlement analysis on Columns H-5A, H-6, and J-5A. In the settlement analyses, we considered that the ground water table is located at a depth of at least 26 feet below existing grade based on our short-term ground water readings. The estimated settlements for the selected footings are presented in Table 8.

Table 8. Estimated Consolidation Settlements for Selected Bell Footings

Footing ID	Footing Size and Depth	S (in)	S_s (in)	S_c (in)	δ (in)
H-5A (Boring B-4)	2.5' Dia., 11 deep	0.92	0.68	0.04	0.20
H-6 (Boring B-4)	5' Dia., 11 deep	0.97	0.71	0.06	0.20
J-5A (Boring B-4)	4.5' Dia., 11 deep	0.99	0.71	0.06	0.22

Notes: (1) $S = S_s + S_c + \delta$, estimated total settlement; S_s = estimated consolidation settlement for sand; S_c = estimated consolidation settlement for clay; δ = estimated immediate (elastic) settlement.

The estimated settlements in Table 8 reasonably compare with the cracks we observed (10 to 20 millimeters) in the east wing (i.e. men's locker room and shower) of the Maintenance Building. It is AEC's opinion that a combination of insufficient allowable bearing capacity and footings that were founded in a relatively soft and thick backfill material (from the sanitary sewer manholes and pipes installed in the walkway area between the Maintenance and Administration Buildings) contributed to the large settlement which has occurred at the Maintenance Building.

Time Rates of Consolidation Settlements: Given the construction date of the Maintenance Building (1988) and considering the relatively small influence zones of the footings, it is AEC's opinion that long-term consolidation settlement of the Maintenance Building footings should have already been completed.

5.2.3 Foundation Remediation

To address the overlarge differential settlement and/or inadequate allowable bearing capacity issue of the existing Maintenance Building foundations, AEC recommends that the men's locker room and shower area be underpinned with either drilled-and-underreamed footings or straight-sided drilled footings, founded at least 12 feet below finished grade. AEC notes that the underpinning will still be founded within the soft clay backfill strata, but deeper underpinning may not be possible given the very limited space and access for construction equipment around the east wing of the Maintenance Building.

<u>Allowable Bearing Capacity:</u> Using a minimum safety factor of 3 for sustained loads and 2 for total loads, drilled-and-underreamed footings (with a maximum diameter equal to or less than 36 inches) at a depth of 12 feet can be designed for a net allowable bearing capacity of 1,600 psf for sustained loads and 2,400 psf for total loads, whichever is critical should be used.

<u>Foundation Spacing:</u> To maintain the integrity of the drilled footings and reduce excessive stress overlap from adjacent foundations, (i) the minimum edge-to-edge clear spacing between the underreams (including new and existing footings) should not be less than 0.6 times the diameter of the larger underream; or (ii) the minimum center-to-center spacing between the adjacent straight-sided drilled footings (including new and existing footings) should be at least 3 times the diameter of the larger drilled shafts.

Evaluation of adequacy of the existing footings for underpinning and design of the pier caps of drilled footings should be performed by a structural engineer.

<u>Underpinning Construction:</u> Foundation underpinning will require a specialty/experienced contractor. There is a possibility that slickensides and/or sand pockets/seams within the clay soils may make underreaming (belling) difficult, and result in potential sloughing or caving-in of the shaft excavation sidewalls during construction, particularly for underreams over 6 feet in diameter. We recommend that a maximum diameter ratio of bell to shaft not exceed 2 to 1. If significant sloughing or caving occurs for drilled-and-underreamed shafts, further footing excavation should be stopped and a reduced bell/shaft ratio or even straight-sided shafts (matching the bell diameter) may be necessary.

Placement of concrete should be accomplished immediately after excavation is completed to reduce potential for sloughing of the foundation soils. Footing excavations should not be left open overnight. No concrete should be placed without the prior approval of the Owner's Representative. Based on Fugro Boring B-1 and AEC Boring B-4, drilled-and-underreamed footings will most likely not encounter groundwater during construction. However, the groundwater level will fluctuate with seasonal rainfall and other climatic events, and may be higher at the time of construction. If ground water is encountered within the footing bearing soils during construction, sump pumps may be used to pump water out from the excavations and soft sediments should be removed. New drilled footings should not be excavated within 2 bell diameters (for bell footings, edge to edge) or 3 shaft diameters (for straight-side drilled shafts, edge-to-edge) of an open footing excavation, or one in which concrete has been placed in the preceding 24 hours, to prevent movement of fresh concrete from the recently filled footing to an adjacent unfilled footing.

The contractor should take measures to prevent surface water from entering into the subsurface soils during and after the foundation remediation. The excavation area at the surface (if any) outside the pier caps should be backfilled with compacted impermeable select fill.

5.3 Chemical Building

A structural plan drawing (with sub-areas of the building indicated) of the Chemical Building is provided on Plate B-7 in Appendix B. According to drawings provided by Parsons, the Chemical Building was constructed in 1988. The 42 foot wide by 92 foot long Chemical Building is supported on a 24 inch thick concrete mat foundation founded at an elevation of 80 feet above MSL. Four chemical tanks (Area A1) are located under a covered area on the north half of the Chemical Building in a recessed pit with a FFE of 82 feet above MSL. The pump room (Area A2), sample room and electrical rooms (Area A3) are located in the center area of the building with a FFE of 86 feet above MSL. The covered walkway is located on the south side of the building (Area A4) with a FFE of 86 feet above MSL. The top of concrete of the surrounding sidewalk and pavement varies from an elevation of approximately 84 to 85.5 feet above MSL.

The Chemical Building is located approximately 10 to 15 feet to the west of the Chlorine Contact Basins, which were constructed at the same time as the Chemical Building. The top of wall of the Chlorine Contact Basins is at an elevation of 84.0 feet above MSL, the FFE of the basins is 64.0 feet, and the mat foundation depth of the basins is at approximately 60.75 feet above MSL. Based on the provided drawings, there is approximately 23 feet of backfill against the Chlorine Contact Basins exterior walls. As a result, the Chemical Building mat foundation is supported on approximately 19 feet of backfill material (from the bottom of the mat to natural to the bottom of the basin excavation); for comparison, AEC encountered 24 and 20 feet of fill in Borings B-8 and B-9, respectively. Mat foundation loadings and footing pressures provided by KIT Professionals are presented on Table 9 below.

Table 9. Chemical Building Mat Foundation Loads

Area ID	Footing Size and Depth	Existing Pressures (psf)	
		Dead Load	Total Load
A1	42.2’x40.4’, 6’ deep	1,300	200
A2 and A3	42.2’x33.7’, 6’ deep	800	200
A4	42.2’x18.4’, 6’ deep	300	200

5.3.1 Allowable Bearing Pressures for Existing Mat Footing

For a mat foundation bearing at 6 feet below existing grade, we calculated a net allowable bearing capacity of 2,400 psf for sustained loads and 3,600 psf for total loads, with FS of 3 and 2 for sustained loads and total loads, respectively. Note that the allowable bearing pressures are based on the borings drilled about 24 to 25 years after the building was constructed; as a result, the subsurface soils have already experienced consolidation.

5.3.2 Existing Mat Footing Settlement Analyses

AEC performed settlement analysis on the Chemical Building mat foundation, based on Borings B-8 and B-9. In the settlement analyses, we considered that the ground water table is located at a depth of 7 feet below existing grade based on our short-term ground water readings. The estimated settlements of the subareas of the mat foundation are presented in Table 10.

Table 10. Estimated Consolidation Settlements for Mat Footing

Area ID	Footing Size and Depth	S (in)	S_s (in)	S_c (in)	δ (in)
A1	42.2’x40.4’, 6’ deep	2.94	0.85	1.48	0.61
A2 and A3	42.2’x33.7’, 6’ deep	1.73	0.61	0.74	0.38
A4	42.2’x18.4’, 6’ deep	0.76	0.28	0.34	0.14

Notes: (1) $\delta = S = S_s + S_c + \delta$, estimated total settlement; S_s = estimated consolidation settlement for sand; S_c = estimated consolidation settlement for clay; δ = estimated immediate (elastic) settlement.

Based on Borings B-8 and B-9, AEC encountered approximately 20 to 24 feet of highly variable sandy clay and clayey sand fill material and a shallow groundwater depth of approximately 6 to 7 feet below grade. It is AEC’s opinion that the differential loading of subareas A1 through A4 (see Table 9) of the foundation, combined with thick highly variable fill materials have caused overlarge differential settlement (resulting in cracks on the CMU block walls, brick exterior, chemical tank footings, and possibly for the suspended walkways at the tank farm). Another possible reason for cracks on the suspended walkways could be from previous chemical spills (for example, chlorides and sulfates can attack reinforcing steel and concrete, respectively).

Time Rates of Consolidation Settlements: Time rates of foundation settlements are plotted as a curve of percent total consolidation settlement versus time for a mat foundation placed at a depth of 6 feet below existing grade on Plate A-23, in Appendix A. The curve is based on the assumption of a 12-month linear construction period for the existing mat footing, i.e. the foundation soils were loaded linearly during construction.
Frequently, the predicted settlement time is longer than that observed in the field for the following reasons: (1) theoretical conditions assumed for the consolidation analysis do not hold in situ because of intermediate lateral drainage, anisotropy in permeability, time dependency of real loading, and the variation of soil properties with effective stress; and (2) the coefficient of consolidation as determined in the laboratory, decreases with sample disturbance, therefore, predicted settlement time tends to be greater than actual time.

5.3.3 Foundation Remediation Measures

Based on the subsurface soils and groundwater encountered in our Borings B-8 and B-9 and the mat foundation of Chemical Building, AEC recommends using compaction grout, or jet grout (or other appropriate methods) to improve the foundation soils.

Compaction Grouting: Compaction grouting, also known as Low Mobility Grouting (LMG), is a grouting technique that displaces and densifies loose granular soils, reinforces fine grained soils, and stabilizes subsurface voids or sinkholes by the staged injection of low-slump, low mobility aggregate grout. Typically, an injection pipe is first advanced to the maximum treatment depth. The low mobility grout is then injected as the pipe is slowly extracted in lifts, creating a column of overlapping grout bulbs. The expansion of the LMG bulbs displaces surrounding soils. When performed in granular soil, compaction grouting increases the surrounding soils density, friction angle, and stiffness. Compaction grouting can be used for raising settled structures, settlement control, and underpinning.

Jet Grouting: Jet Grouting is a grouting technique that creates in situ geometries of soilcrete (grouted soil), using a grouting monitor attached to the end of a drill stem. The jet grout monitor is advanced to the maximum treatment depth, at which time high velocity grout jets are initiated from ports in the side of the monitor. The high pressure, high velocity erosive jets of cement grout erode and mix the in situ soil as the drill stem and jet grout monitor are rotated and raised. Jet grouting can be used for settlement control and underpinning.

It is the Contractor's responsibility to select the appropriate grouting depths, spacing, and grouting pressures which should not cause adverse impact on the existing mat foundation and structures above. Contact information for compaction grouting and jet grouting is listed below:

Dennis W. Boehm, P.E. - Vice President
Hayward Baker
509 N. Sam Houston Parkway E., Suite 300
Houston, TX 77060
Tel: 281-668-1870, Fax: 281-668-1871
E-mail: dwboehm@HaywardBaker.com

5.4 Select Fill

Select fill (if need) should consist of uniform, non-active inorganic lean clays with a PI between 10 and 20 percent, and more than 50 percent passing a No. 200 sieve. Excavated material delivered to the site for use as select fill shall not have clay clods with PI greater than 20, clay clods greater than 2 inches in diameter, or contain sands/silts with PI less than 10. Prior to construction, the Contractor should determine if he or she can obtain qualified select fill meeting the above select fill criteria.

As an alternative to imported fill, on-site soils excavated during construction can be stabilized with a minimum of 6 percent hydrated lime (by dry soil weight), as determined by lime-series curve or pH method in a laboratory prior to construction. Lime stabilization should be done in general accordance with Section 02336 of the 2011 City of Houston Standard Construction Specifications (COHSCS). AEC prefers using stabilized on-site clay as select fill since compacted lime-stabilized clay generally has high shear strength, low compressibility, and relatively low permeability. Blended or mixed soils (sand and clay) should not be used as select fill.

All imported material intended for use as select fill should be tested prior to use to confirm that it meets select fill criteria. Select fill should be placed in loose lifts not exceeding 8 inches in thickness. Backfill within 3 feet of walls or columns should be placed in loose lifts no more than 4-inches thick and compacted using hand tampers, or small self-propelled compactors. The select fill should be compacted to a minimum of 95 percent of the ASTM D 698 (Standard Proctor) maximum dry unit weight at a moisture content ranging between optimum and 3 percent above optimum.

At least one Atterberg Limits and one percent passing a No. 200 sieve test shall be performed for each 5,000 square feet (sf) of placed fill, per lift (with a minimum of one set of tests per lift), to determine whether it meets select fill requirements. Prior to placement of concrete, the moisture contents of the top 2 lifts of compacted select fill shall be re-tested (if there is an extended period of time between fill placement and pavement construction) to determine if the in-place moisture content of the lifts have been maintained at the required moisture requirements.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 Site Preparation and Grading

To mitigate site problems that may develop following prolonged periods of rainfall, it is essential to have adequate drainage to maintain a relatively dry and firm surface prior to starting any work at the site. Adequate drainage should be maintained throughout the construction period. Methods for controlling surface runoff and ponding include proper site grading, berm construction around exposed areas, and installation of sump pits with pumps.

6.2 Construction Monitoring

Site preparation (including clearing and proof-rolling), earthwork operations, foundation construction, and subgrade preparation should be monitored by qualified geotechnical professionals to check for compliance with project documents and changed conditions, if encountered.

6.3 Monitoring of Existing Structures

Existing structures in the vicinity of the proposed improvements should be closely monitored prior to, during, and for a period after the remediation. Any structures/underground utilities located close to the remediation should be surveyed prior to construction and pre-existing conditions of such structures and their vicinity be adequately recorded. This can be accomplished by conducting a pre-construction survey, taking photographs and/or video film, and documenting existing elevations, cracks, settlements, and other existing distress in the structures. The monitoring may include establishment of elevation monitor stations, crack gauges, and inclinometers, as required. The monitoring should be performed before, periodically during, and after construction. The data should be reviewed by qualified engineers in a timely manner to evaluate the impact on existing structures/utilities and develop plans to mitigate the impact, should it be necessary. The Contractor should be responsible for monitoring existing structures/underground utilities and taking necessary action to mitigate impact to these facilities.

7.0 GENERAL

AEC should be allowed to review construction documents and specifications prior to release to check that the geotechnical recommendations and design criteria presented herein are properly interpreted.

The information contained in this report summarizes conditions found on the dates the borings were drilled. The attached boring logs are true representations of the soils encountered at the specific boring locations on the date of drilling. Due to variations encountered in the subsurface conditions across the site, changes in soil conditions from those presented in this report should be anticipated. AEC should be notified immediately when conditions encountered during construction are significantly different from those presented in this report.

8.0 LIMITATIONS

The investigation was performed using the standard level of care and diligence normally practiced by recognized geotechnical engineering firms in this area, presently performing similar services under similar circumstances. The report has been prepared exclusively for the project and location described in this report, and is intended to be used in its entirety. If pertinent project details change or otherwise differ from those described herein, AEC should be notified immediately and retained to evaluate the effect of the changes on the recommendations presented in this report, and revise the recommendations if necessary. The scope of services does not include a fault investigation. The recommendations presented in this report should not be used for other structures located at this site or similar structures located at other sites, without additional evaluation and/or investigation.

ENGINEERING CORP.

9.0 CLOSING REMARKS

AEC appreciates the opportunity to be of service on this project and looks forward to our continuing association during the construction phase of this project and on future projects.

AVILES ENGINEERING CORPORATION
(TBPE Firm Registration No. F-42)

STATE OF TEXAS
SHOU TING HU
84686
LICENSED
PROFESSIONAL ENGINEER
4/24/2013

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Principal Engineer

April 24, 2013

Reports Submitted:	3	Parsons, Inc.
	1	File

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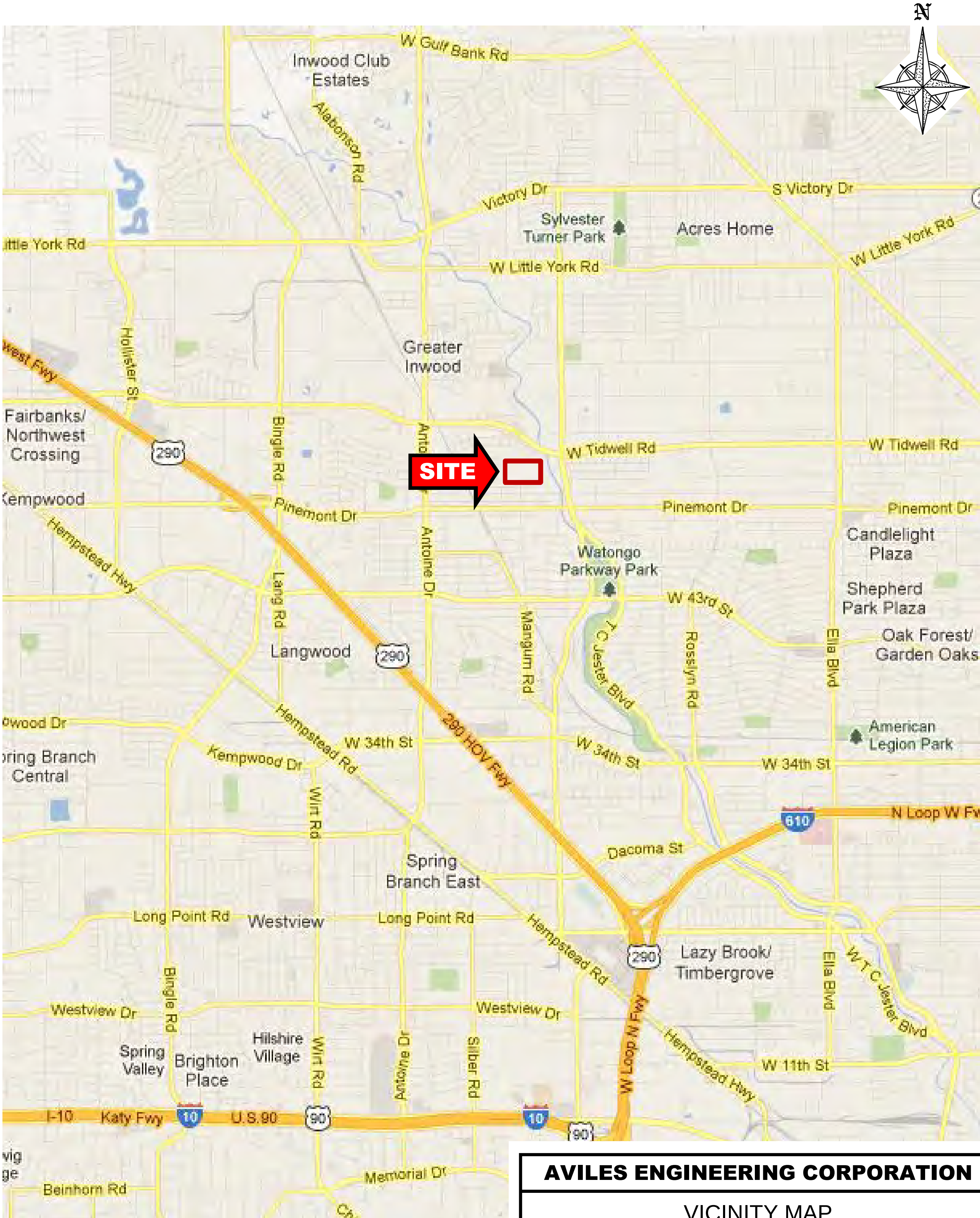
APPENDIX A

Plate A-1	Vicinity Map
Plate A-2	Boring Location Plan
Plates A-3 to A-11	Boring Logs
Plate A-12	Key to Symbols
Plate A-13	Classification of Soils for Engineering Purposes
Plate A-14	Terms Used on Boring Logs
Plate A-15	ASTM & TXDOT Designation for Soil Laboratory Tests
Plates A-16 and A-17	Sieve Analysis Results
Plates A-18 to A-22	Consolidation Test Results
Plate A-23	Time-rate of Consolidation - Chemical Building Mat Foundation



AVILES ENGINEERING CORPORATION

VICINITY MAP

C.O.H. NORTHWEST WWTP IMPROVEMENTS
HOUSTON, TEXAS

AEC PROJECT NO.:	DATE:	
G128-12	9-11-12	
APPROX. SCALE: N.T.S.	DRAFTED BY: BpJ	PLATE NO.: PLATE A-1

LEGEND:

B-# (X')	*TRUCK RIG BORING LOCATION AND DEPTH*
B-# (X')	*PORTABLE RIG BORING LOCATION AND DEPTH*

NOTE: ALL BORING LOCATIONS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

BORING LOCATION PLAN

C.O.H. NORTHWEST WWTP IMPROVEMENTS
HOUSTON, TEXAS

AEC PROPOSAL NO.:	DATE:	
G128-12	07-10-12	
APPROX. SCALE: 1" = 40'	DRAFTED BY: BpJ	PLATE NO.: PLATE A-2

AVILES ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

PROJECT: **Northwest WWTP Improvements** BORING **B-1**

DATE **7/18/12** TYPE **4" Wet Rotary** LOCATION **See Boring Location Plan**

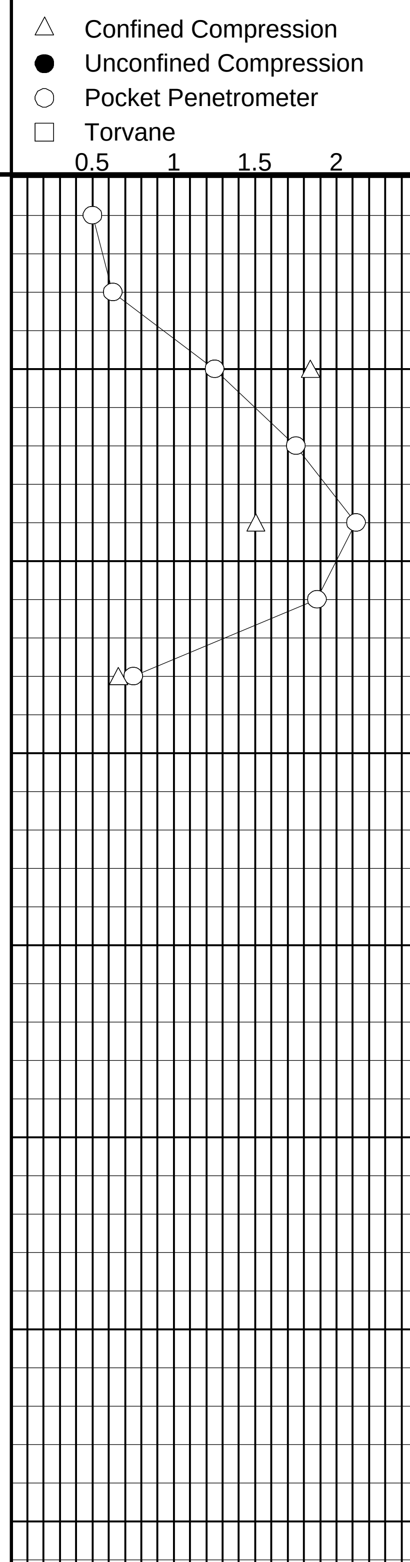
DESCRIPTION

Survey Coordinates (ft):
Easting: 3089642.88
Northing: 13872797.16
Elevation: 76.74

Depth (ft)	Description
0–0.6	Pavement: 7" concrete
0.6–0.8	Base: 3" sand and gravel
0.8–4	Fill: firm to stiff, light brown and gray Fat Clay w/Sand (CH) -with gravel 1'-2' -brown and tan, with sand pockets 2'-4'
4–14	Stiff to hard, gray and reddish tan Sandy Lean Clay (CL) -with ferrous stains 4'-6' -light gray and brown 6'-8' -light gray 8'-14', with ferrous stains 8'-12' -with silty sand seams 12'-14'
14–18	Medium dense to dense, light gray Silty Sand (SM) -with clay seams 16'-18'
18–27	Medium dense, light gray Poorly Graded Sand w/Silt (SP-SM) -caved in at 26.8' at 24 hours
27–36	Medium dense to very dense, light tan Poorly Graded Sand (SP), with silt seams -medium dense 27'-36'

Depth (ft)	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
1		17					
3		27	96	74	51	16	35
5		17	114				
7		16		62	35	14	21
9		18	113				
11		20			36	16	20
13		19	109				
15	25	11		23			
17	34	16					
19	20	5					
24	24	20		12			
29	22	24					
34	30	23					

SHEAR STRENGTH, TSF



BORING DRILLED TO **30** FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT **25** FEET WHILE DRILLING
WATER LEVEL AT **26.8** FEET AFTER **24 HRS**
DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **CHL**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: **Northwest WWTP Improvements** BORING **B-1**

DATE **7/18/12** TYPE **4" Wet Rotary** LOCATION **See Boring Location Plan**

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	SHEAR STRENGTH, TSF (△ Confined Compression; ● Unconfined Compression; ○ Pocket Penetrometer; □ Torvane; 0.5 1 1.5 2)	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
			Poorly Graded Sand (SP) (cont.) -very dense 38'-40'	64	21			2			
40			Termination Depth = 40 Feet Boring caved at 26'-9" after 24 hours								
45											
50											
55											
60											
65											
70											

BORING DRILLED TO **30** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **25** FEET WHILE DRILLING

WATER LEVEL AT **26.8** FEET AFTER **24 HRS**

DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **CHL**

AVILES ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

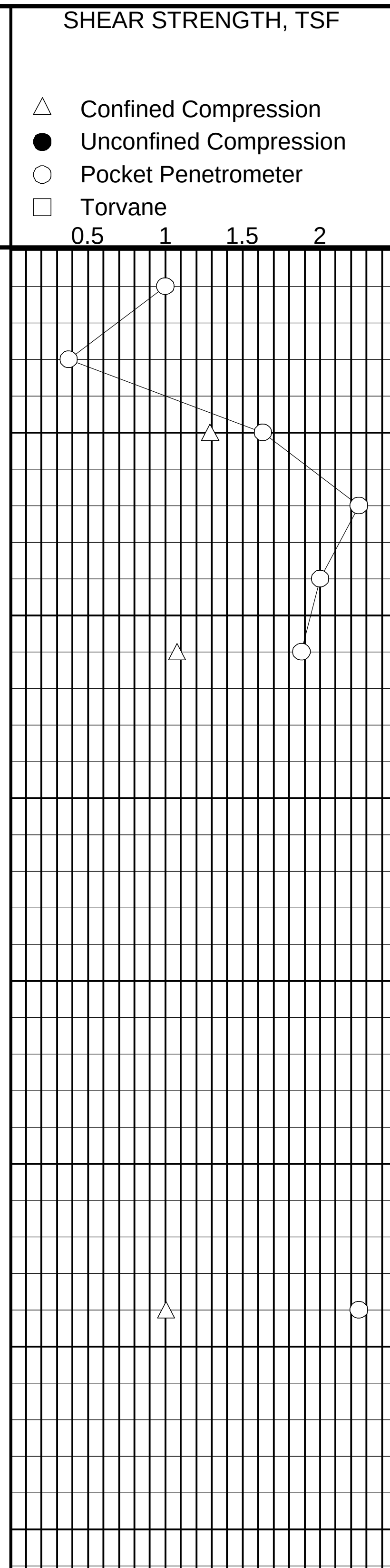
PROJECT: **Northwest WWTP Improvements** BORING **B-2**

DATE **7/18/12** TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

Survey Coordinates (ft):
Easting: 3089722.99
Northing: 13872755.46
Elevation: 76.29

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 8" asphalt							
	Base: 3" sand, shell, and gravel, with clay partings		14		42	28	14	14
	Fill: gray and tan Clayey Sand (SC) -with gravel 1'-2'		11	112				
5	-light gray and brown, with fat clay pockets 2'-4'		13	120				
	Fill: very stiff, gray and tan Lean Clay (CL), with silty sand pockets		17		70	44	18	26
	Very stiff to hard, light gray Lean Clay w/ Sand (CL) -with ferrous stains 6'-8'		19					
10	-with abundant silt seams, ferrous stains, and calcareous nodules 10'-12'		17	114				
	Very stiff, light gray Sandy Lean Clay (CL)	19	19		57			
15	-light gray and brown, with abundant silt seams, gravel, and calcareous nodules	16	16					
	Medium dense, light gray Silty Sand (SM) -with silt seams 16'-18'	17	11					
	-light tan 18'-20'	29	6		15			
20								
	Medium dense, light tan Poorly Graded Sand w/Silt (SP-SM), with clayey silt pockets -caved in at 22.2' at 24 hours	27	6		11			
25								
	Very stiff to hard, gray and tan Lean Clay (CL), with silty sand pockets		20	103		44	16	28
30	Termination Depth = 30 Feet Boring caved at 22'-2" after 24 hours							
35								

SHEAR STRENGTH, TSF



BORING DRILLED TO **30** FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING
WATER LEVEL AT **22.2** FEET AFTER **24 HRS**
DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **CHL**

PROJECT NO. G128-12 **PLATE A-4**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: **Northwest WWTP Improvements** BORING **B-3**

DATE ______ TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION *Survey Coordinates (ft):* *Easting:* *Northing:* *Elevation:*	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	SHEAR STRENGTH, TSF △ Confined Compression ● Unconfined Compression ○ Pocket Penetrometer □ Torvane 0.5 1 1.5 2	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0			Boring Deleted								
5											
10											
15											
20											
25											
30											
35											

BORING DRILLED TO **n/a** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING

WATER LEVEL AT **n/a** FEET AFTER **24 HRS**

DRILLED BY ______ CHECKED BY ______ LOGGED BY ______

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

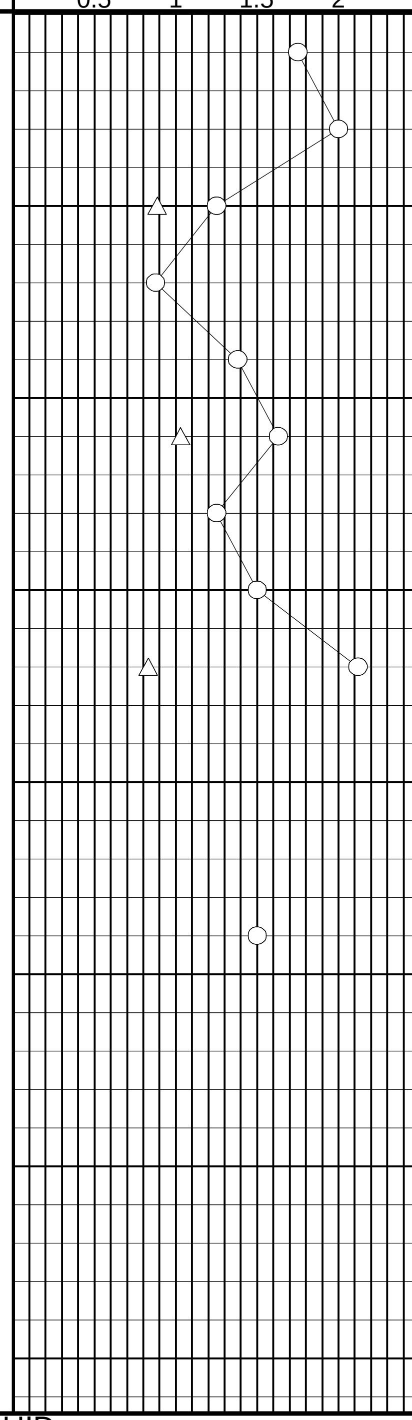
PROJECT: **Northwest WWTP Improvements** BORING **B-4**

DATE **7/18/12** TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

DESCRIPTION

Survey Coordinates (ft):
Easting: 3090006.54
Northing: 13872692.81
Elevation: 77.01

SHEAR STRENGTH, TSF
△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane
0.5 1 1.5 2



DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 7" concrete				55	33	14	19
	Base: 3" sand and gravel		17					
	Fill: stiff to hard, brown and gray Sandy Lean Clay (CL), with fat clay pockets -with gravel 1'-2'				64			
	-brown 2'-8', with silty sand pockets 2'-4'		15	114				
5			17	113				
	-with silty sand seams 6'-18'				58	34	14	20
			19					
	-brown and tan, with gravel 8'-10'		17					
10	-brown 10'-14'				56	33	14	19
			17	114				
			16					
	-brown and tan 14'-16'					32	14	18
15			16					
			16	113				
	Medium dense, light gray Silty Sand (SM)				13			
20		17	5					
	Very stiff, light gray and tan Lean Clay (CL), with silty sand pockets							
			18					
25	Medium dense, light tan Poorly Graded Sand (SP) -caved in at 26.2' at 24 hours							
					5			
		24	22					
30	Termination Depth = 30 Feet Boring caved at 26'-2" after 24 hours							
35								

BORING DRILLED TO **30** FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING
WATER LEVEL AT **26.2** FEET AFTER **24 HRS**
DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **CHL**

PROJECT NO. G128-12 **PLATE A-6**

PROJECT: **Northwest WWTP Improvements**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

BORING **B-5**

DATE **7/18/12** TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

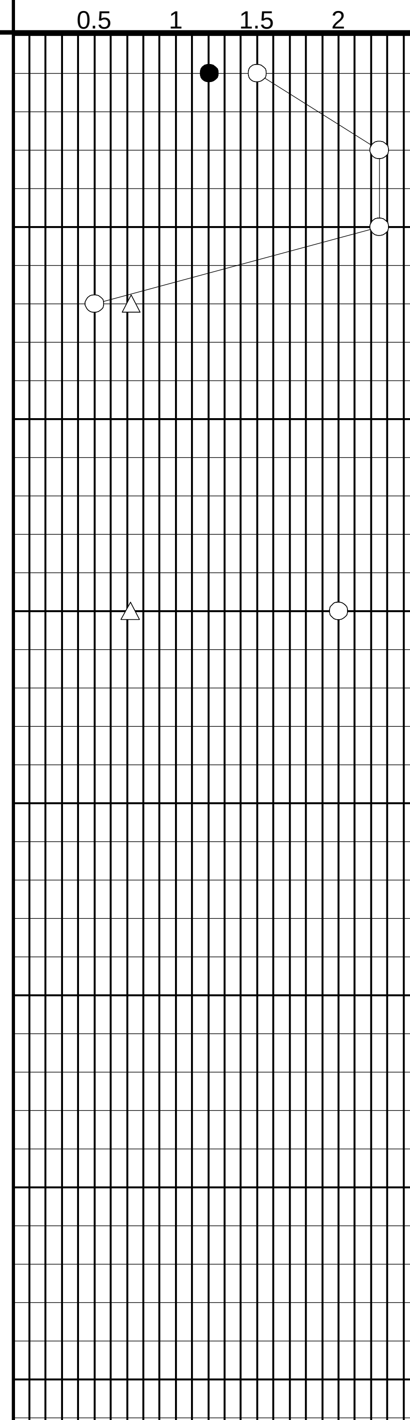
DESCRIPTION

Survey Coordinates (ft):
Easting: 3089884.92
Northing: 13872728.43
Elevation: 78.26

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 9" asphalt				51	32	14	18
	Base: 3" sand and gravel		14	118				
	Fill: very stiff to hard, brown Sandy Lean Clay (CL), with silty sand seams -with gravel 1'-2' -gray and tan, with wood pieces 2'-4'		11	121	49	30	15	15
5	Fill: gray and tan Clayey Sand (SC), with silty sand seams -dark brown 6'-8'		12					
			15	116				
	Possible fill: medium dense, light gray Silty Sand (SM)	29	11					
10	-with clayey sand pockets 10'-14'	24	7		14			
		28	7					
15	Possible fill: gray and brown Clayey Sand (SC), with ferrous nodules		15	113	29			
	Hard, light gray Sandy Lean Clay (CL)	30	18		68			
20	Medium dense, light gray Poorly Graded Sand w/Silt (SP-SM)	19	8					
	-caved in at 21.9' at 24 hours							
25		27	4		8			
	Very dense, light gray Silty Sand (SM), with fat clay seams	51	22					
30	Termination Depth = 30 Feet Boring caved at 21'-10" after 24 hours							
35								

SHEAR STRENGTH, TSF

△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane



BORING DRILLED TO **30** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING

WATER LEVEL AT **21.9** FEET AFTER **24 HRS**

DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **CHL**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: **Northwest WWTP Improvements** BORING **B-6**

DATE ______ TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION *Survey Coordinates (ft):* *Easting:* *Northing:* *Elevation:*	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	SHEAR STRENGTH, TSF △ Confined Compression ● Unconfined Compression ○ Pocket Penetrometer □ Torvane 0.5 1 1.5 2	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0			Boring Deleted								
5											
10											
15											
20											
25											
30											
35											

BORING DRILLED TO **n/a** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING

WATER LEVEL AT **n/a** FEET AFTER **24 HRS**

DRILLED BY ______ CHECKED BY ______ LOGGED BY ______

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: **Northwest WWTP Improvements** BORING **B-7**

DATE ______ TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION *Survey Coordinates (ft):* *Easting:* *Northing:* *Elevation:*	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	SHEAR STRENGTH, TSF △ Confined Compression ● Unconfined Compression ○ Pocket Penetrometer □ Torvane 0.5 1 1.5 2	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0			Boring Deleted								
5											
10											
15											
20											
25											
30											
35											

BORING DRILLED TO **n/a** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING

WATER LEVEL AT **n/a** FEET AFTER **24 HRS**

DRILLED BY ______ CHECKED BY ______ LOGGED BY ______

PROJECT: **Northwest WWTP Improvements**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

BORING **B-8**

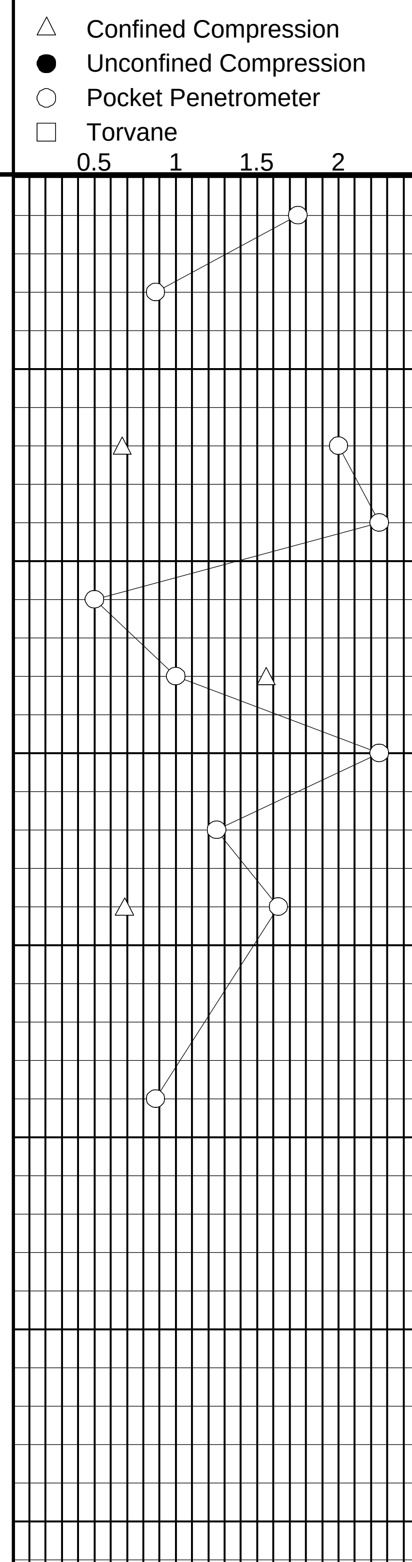
DATE **7/18/12** TYPE **4" Dry Auger** LOCATION **See Boring Location Plan**

DESCRIPTION

Survey Coordinates (ft):
Easting: 3090126.00
Northing: 13872751.15
Elevation: 74.80

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 8.5" concrete				47	32	15	17
	Base: 3" sand and gravel		15					
	Fill: gray and brown Clayey Sand (SC), with fat clay and silty sand pockets		17	108				
5	Fill: light gray Silty Sand (SM), with lean clay pockets	26	14		41			
	Fill: brown and tan Clayey Sand (SC), with fat clay and silty sand pockets		15	112				
			17	111				
10	-brown 10'-12'		16		43	29	15	14
	Fill: stiff to hard, tan and brown Sandy Lean Clay (CL), with fat clay and silty sand pockets		15	116				
15			16					
	-brown 16'-18'		17		53	35	15	20
			16	114				
20	Fill: brown Clayey Sand (SC), with fat clay pockets							
			19		48	33	14	19
25	Medium dense, light gray Silty Sand (SM)							
30		11	21					
	Termination Depth = 30 Feet Boring caved at 6'-9" after 24 hours							
35								

SHEAR STRENGTH, TSF



BORING DRILLED TO **30** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **n/a** FEET WHILE DRILLING

WATER LEVEL AT **6.7** FEET AFTER **24 HRS**

DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **CHL**

PROJECT: **Northwest WWTP Improvements**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

BORING **B-9**

DATE **7/20/12** TYPE **4" Dry Auger/Wet Rotary** LOCATION **See Boring Location Plan**

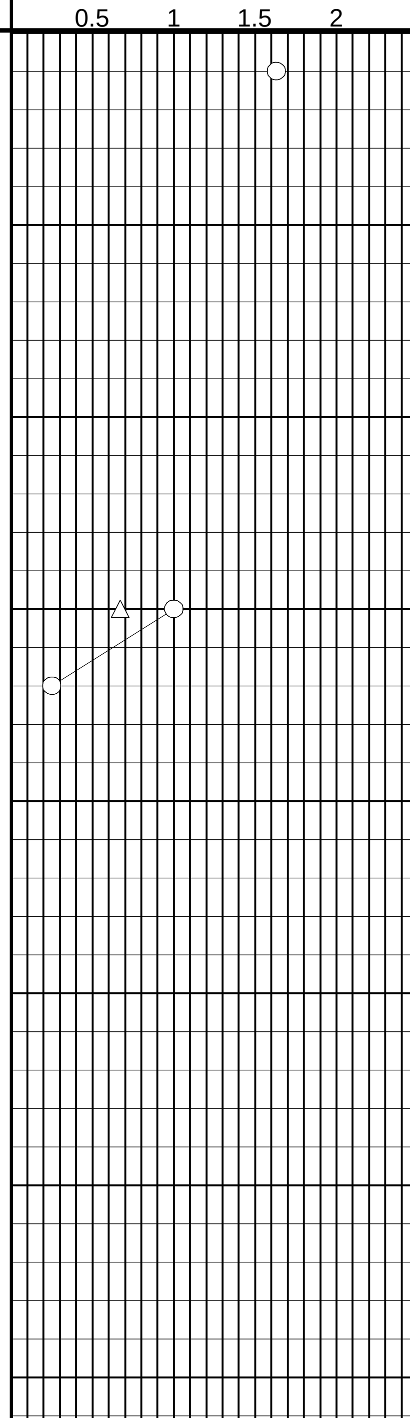
DESCRIPTION

Survey Coordinates (ft):
Easting: 3090192.64
Northing: 13872685.64
Elevation: 73.77

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Fill: very stiff, brown and tan Sandy Lean Clay (CL), with gravel and silty sand layers		14		51	30	14	16
	Fill: loose to dense, light tan Clayey Sand (SC)	5	23					
5	-light gray 4'-6'	30	17		31			
	Fill: medium dense to dense, light tan Silty Sand (SM) -with fat clay pockets 6'-8'	24	15					
10	-light gray 8'-10', with clayey sand pockets 8'-12'	41	15		24			
		19	16					
	Fill: very stiff, brown and tan Sandy Fat Clay (CH)	19	19		59			
15	Fill: soft to stiff, tan and brown Lean Clay (CL), with silty sand seams -with fat clay pockets 14'-16'		16	115				
			19			25	15	20
	Fill: light tan Silty Sand (SM), with clayey sand pockets		16		31			
20	Medium dense to very dense, light brown Silty Sand (SM)							
25		23	22					
30	-with clayey sand pockets 28'-30'	56	21		14			
35	Hard, light gray Fat Clay (CH), with silty sand seams	32	30					

SHEAR STRENGTH, TSF

△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane



BORING DRILLED TO **25** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **23** FEET WHILE DRILLING

WATER LEVEL AT **7** FEET AFTER **24 HRS**

DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **RJM**

AVILES ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

PROJECT: **Northwest WWTP Improvements** BORING **B-9**

DATE **7/20/12** TYPE **4" Dry Auger/Wet Rotary** LOCATION **See Boring Location Plan**

SHEAR STRENGTH, TSF: △ Confined Compression; ● Unconfined Compression; ○ Pocket Penetrometer; □ Torvane (scale 0.5, 1, 1.5, 2)

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
	Stiff to very stiff, reddish tan Sandy Lean Clay (CL), with silt seams, fat clay pockets, and siltstone fragments		19	107				
40								
	Very stiff, red Fat Clay (CH), with slickensides		27			64	24	40
45								
		23	29					
50	Termination Depth = 50 Feet Boring caved at 23'-4" after 24 hours							
55								
60								
65								
70								

BORING DRILLED TO **25** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **23** FEET WHILE DRILLING

WATER LEVEL AT **7** FEET AFTER **24 HRS**

DRILLED BY **Van & Sons** CHECKED BY **WW** LOGGED BY **RJM**

KEY TO SYMBOLS

Symbol Description

Strata symbols

Paving

Fill

Low plasticity clay

Silty sand

Poorly graded sand with silt

Poorly graded sand

High plasticity clay

Misc. Symbols

Water table depth during drilling

Subsequent water table depth

Pocket Penetrometer

Confined Compression

Unconfined Compression

Soil Samplers

Undisturbed thin wall Shelby tube

Standard penetration test

ENGINEERING CORP.

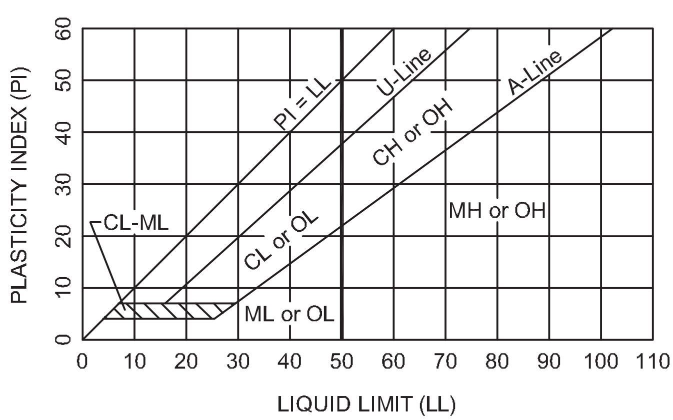
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation D-2487

MAJOR DIVISIONS				GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (Less than 50% of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well-graded gravel, well-graded gravel with sand
				GP	Poorly-graded gravel, poorly-graded gravel with sand
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	GM	Silty gravel, silty gravel with sand
			Limits plot above "A" line & hatched zone on plasticity chart	GC	Clayey gravel, clayey gravel with sand
	SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well-graded sand, well-graded sand with gravel
				SP	Poorly-graded sand, poorly-graded sand with gravel
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	SM	Silty sand, silty sand with gravel
			Limits plot above "A" line & hatched zone on plasticity chart	SC	Clayey sand, clayey sand with gravel
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS AND CLAYS (Liquid Limit Less Than 50%)			ML	Silt, silt with sand, silt with gravel, sandy silt, gravelly silt
				CL	Lean clay, lean clay with sand, lean clay with gravel, sandy lean clay, gravelly lean clay
				OL	Organic clay, organic clay with sand, sandy organic clay, organic silt, sandy organic silt
	SILTS AND CLAYS (Liquid Limit 50% or More)			MH	Elastic silt, elastic silt with sand, sandy elastic silt, gravelly elastic silt
				CH	Fat clay, fat clay with sand, fat clay with gravel, sandy fat clay, gravelly fat clay
				OH	Organic clay, organic clay with sand, sandy organic clay, organic silt, sandy organic silt

NOTE: Coarse soils between 5% and 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone of the plasticity chart are to have dual symbols.

PLASTICITY CHART



Equation of A-Line: Horizontal at PI=4 to LL=25.5, then PI=0.73(LL-20)

Equation of U-Line: Vertical at LL=16 to PI=7, then PI=0.9(LL-8)

DEGREE OF PLASTICITY OF COHESIVE SOILS

Degree of Plasticity	Plasticity Index
None	0 - 4
Slight	5 - 10
Medium	11 - 20
High	21 - 40
Very High	>40

SOIL SYMBOLS

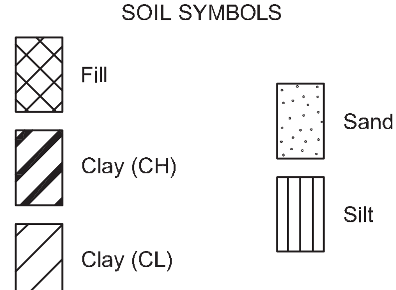


PLATE A-13

ENGINEERING CORP.

TERMS USED ON BORING LOGS

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

	6"	3"	3/4"	#4	#10	#40	#200	
BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		
	152	76.2	19.1	4.76	2.00	0.420	0.074	0.002

SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

Consistency	Undrained Shear Strength, Kips per Sq. ft.
Very Soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	greater than 4.00

RELATIVE DENSITY OF COHESIONLESS SOILS FROM STANDARD PENETRATION TEST

Very Loose	<4 bpf
Loose	5-10 bpf
Medium Dense	11-30 bpf
Dense	31-50 bpf
Very Dense	>50 bpf

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows per Foot	Description
25	25 blows driving sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows driving sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows driving sampler 3 inches, during initial 6-inches seating interval.

NOTE: To avoid change to sampling tools, driving is limited to 50 blows during or after seating interval.

DRY STRENGTH ASTM D2488

None	Dry specimen crumbles into powder with mere pressure of handling
Low	Dry specimen crumbles into powder with some finger pressure
Medium	Dry specimen breaks into pieces or crumbles with considerable pressure
High	Dry specimen cannot be broken with finger pressure, it can be broken between thumb and hard surface
Very High	Dry specimen cannot be broken between thumb and hard surface

MOISTURE CONDITION ASTM D2488

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the easiness of breaking along these planes.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil types.
Interlayered	Soil sample composed of alternating layers of different soil types.
Intermixed	Soil sample composed of pockets of different soil types and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of calcium material.

ASTM & TXDOT DESIGNATION FOR SOIL LABORATORY TESTS

NAME OF TEST	ASTM TEST DESIGNATION	TXDOT TEST DESIGNATION
Moisture Content	D 2216	Tex-103-E
Specific Gravity	D 854	Tex-108-E
Sieve Analysis	D 421 D 422	Tex-110-E (Part 1)
Hydrometer Analysis	D 422	Tex-110-E (Part 2)
Minus No. 200 Sieve	D 1140	Tex-111-E
Liquid Limit	D 4318	Tex-104-E
Plastic Limit	D 4318	Tex-105-E
Shrinkage Limit	D 427	Tex-107-E
Standard Proctor Compaction	D 698	Tex-114-E
Modified Proctor Compaction	D 1557	Tex-113-E
Permeability (constant head)	D 2434	-
Consolidation	D 2435	-
Direct Shear	D 3080	-
Unconfined Compression	D 2166	-
Unconsolidated-Undrained Triaxial	D 2850	Tex-118-E
Consolidated-Undrained Triaxial	D 4767	Tex-131-E
Pinhole Test	D 4647	-
California Bearing Ratio	D 1883	-
Unified Soil Classification System	D 2487	Tex-142-E

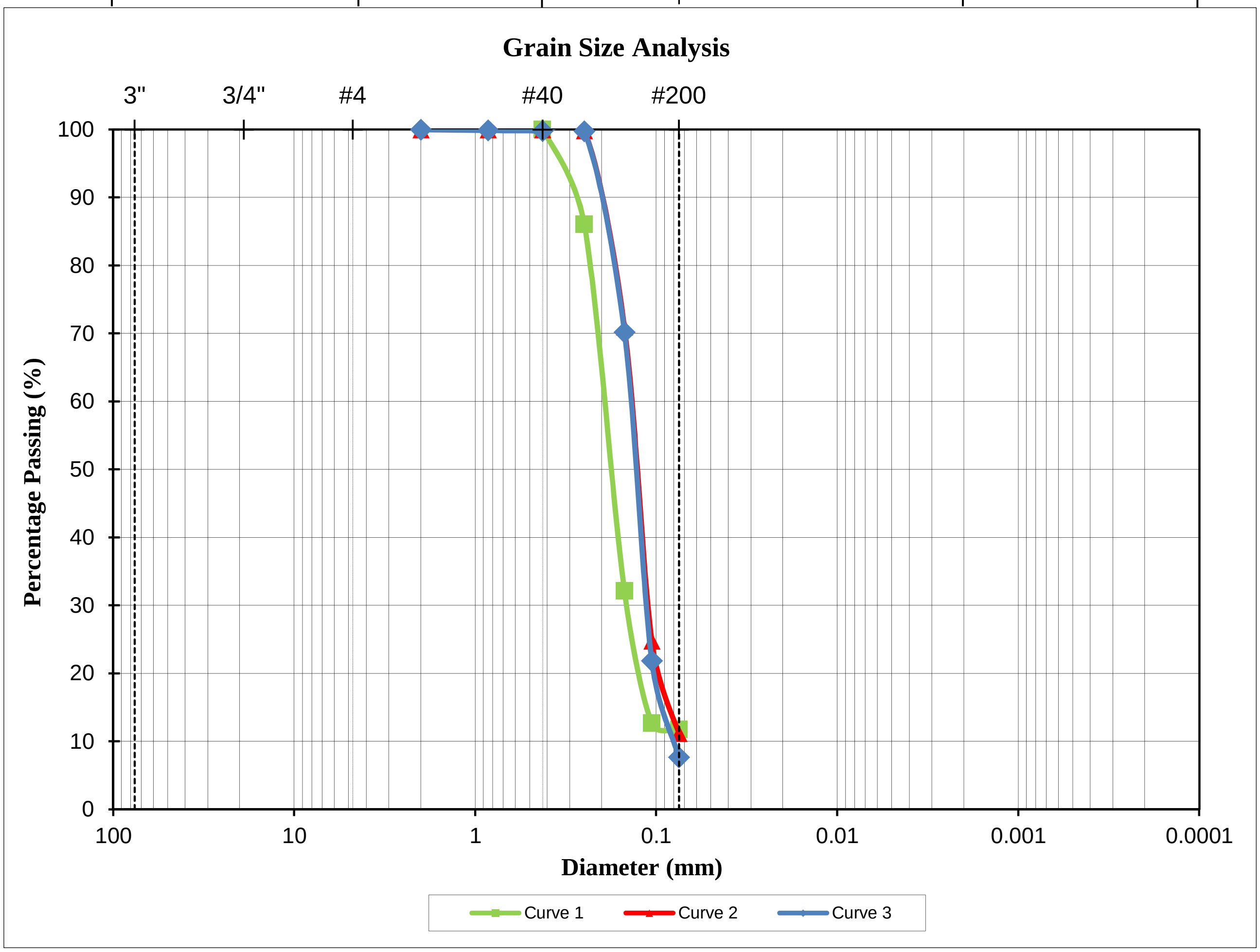
AVILES ENGINEERING CORPORATION

Consulting Engineers - Geotechnical, Construction Materials Testing, Environmental

GRAIN SIZE ANALYSIS - SIEVE

Project : Northwest WWTP Improvements **Job No.:** G128-12
Location of Project: Houston, Texas **Date of Testing:** 7/31/2012

	Gravel	Sand		Silt	Clay	
		Coarse to Medium	Fine			



Curve	Boring	Depth (ft)	Soil Description	Cu	Cc
1	B-1	23-25	Poorly Graded Sand with Silt (SP-SM)	N/A	N/A
2	B-2	23-25	Poorly Graded Sand with Silt (SP-SM)	N/A	N/A
3	B-5	23-25	Poorly Graded Sand with Silt (SP-SM)	1.76	1.14

PLATE A-16

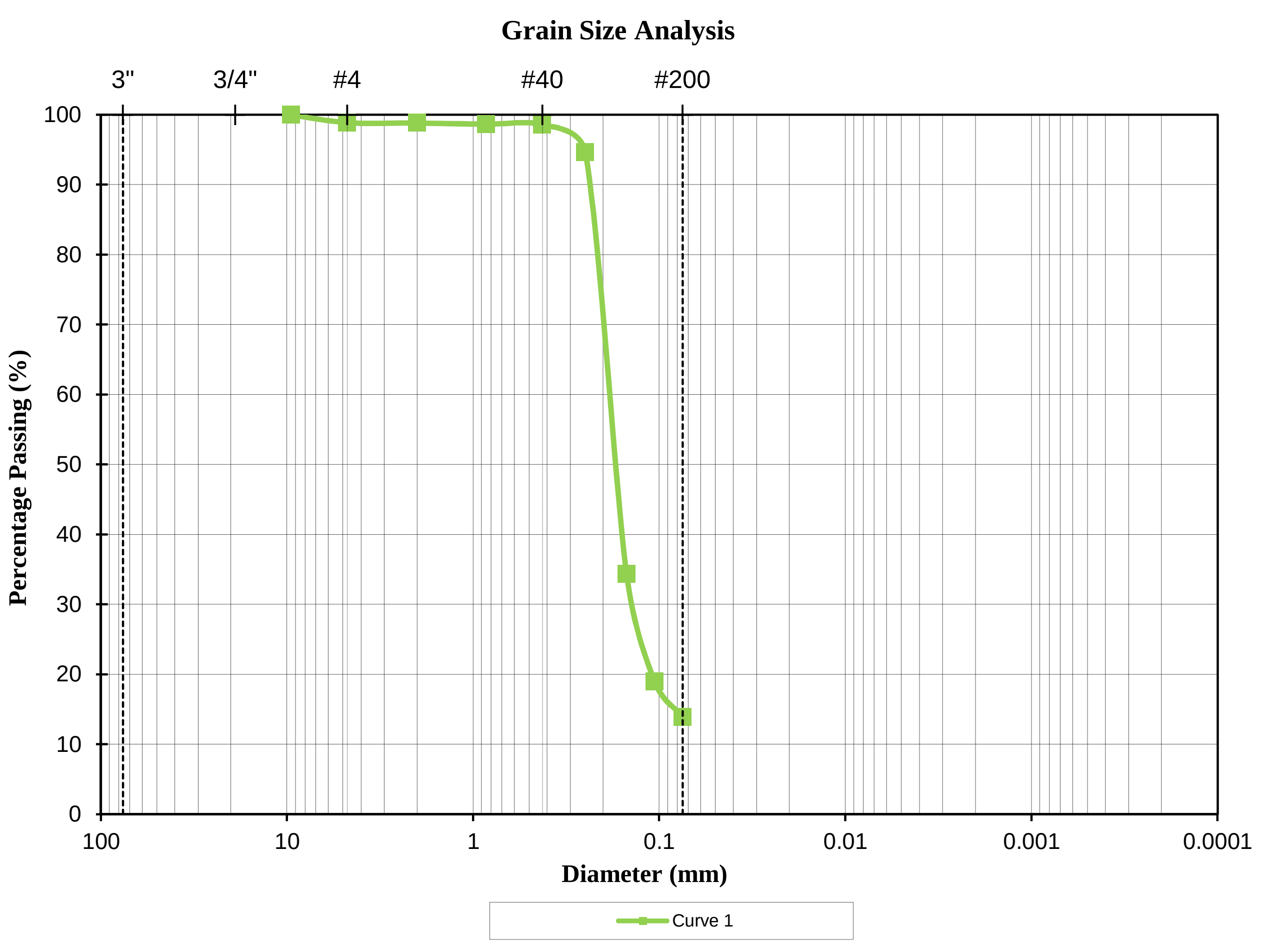
AVILES ENGINEERING CORPORATION

Consulting Engineers - Geotechnical, Construction Materials Testing, Environmental

GRAIN SIZE ANALYSIS - SIEVE

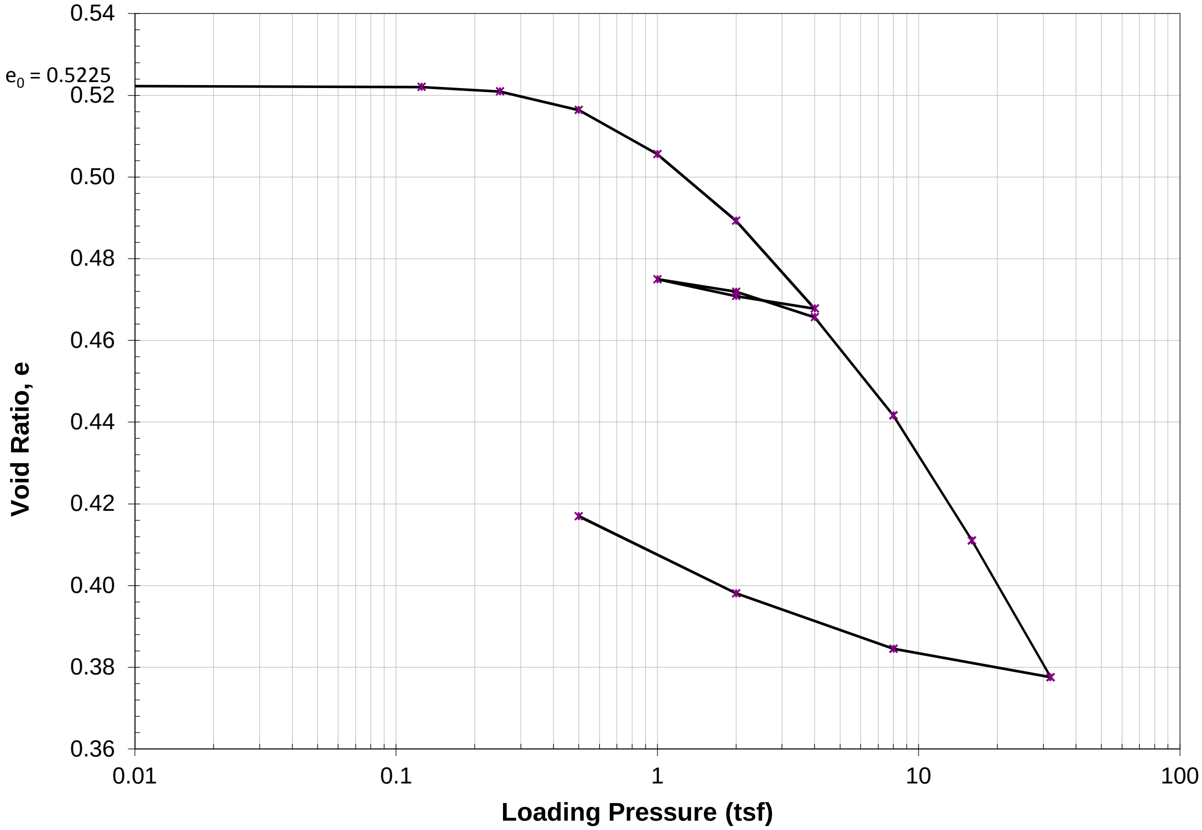
Project : Northwest WWTP Improvements **Job No.:** G128-12
Location of Project: Houston, Texas **Date of Testing:** 7/31/2012

Gravel	Sand: Coarse to Medium	Sand: Fine	Silt	Clay



Curve	Boring	Depth (ft)	Soil Description	Cu	Cc
1	B-9	28-30	Silty Sand (SM)	N/A	N/A

CONSOLIDATION TEST RESULTS



Project No.: G128-12 | Project: Northwest WWTP Improvements

Sample ID: B-1, 10 to 12 feet

Sample Description: Light gray Sandy Lean Clay (CL) | Dry Unit Weight (γ_d): 108 pcf

Estimated Consolidation Index (Cc): 0.1129 | Estimated Recompression Index (Cr): 0.0130

Estimated OCR: 3.6 | Estimated Preconsolidation Pressure (Pc): 2.5 tsf

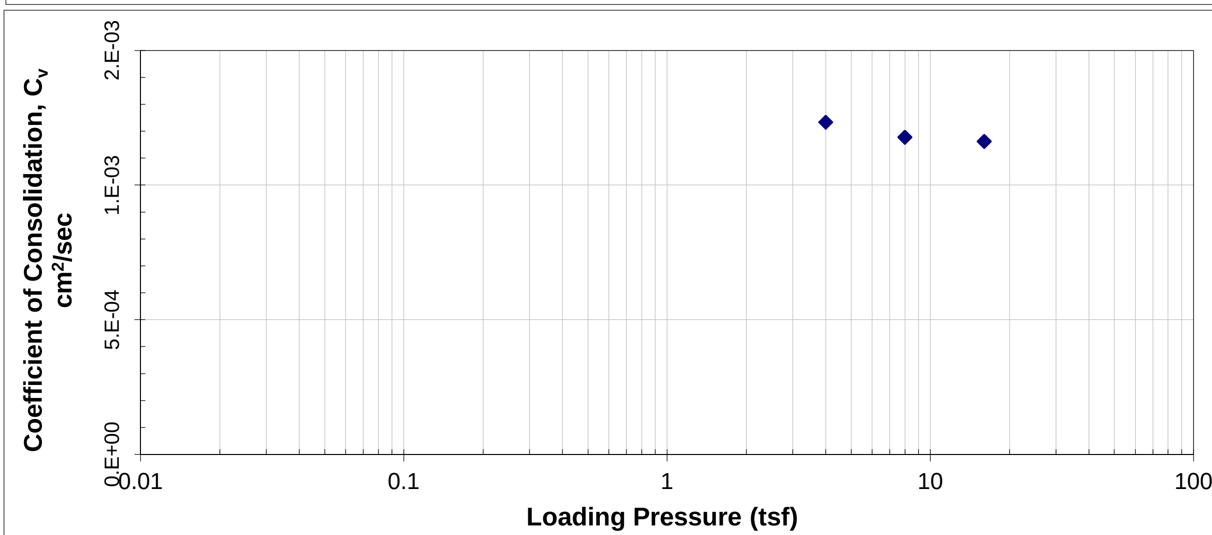
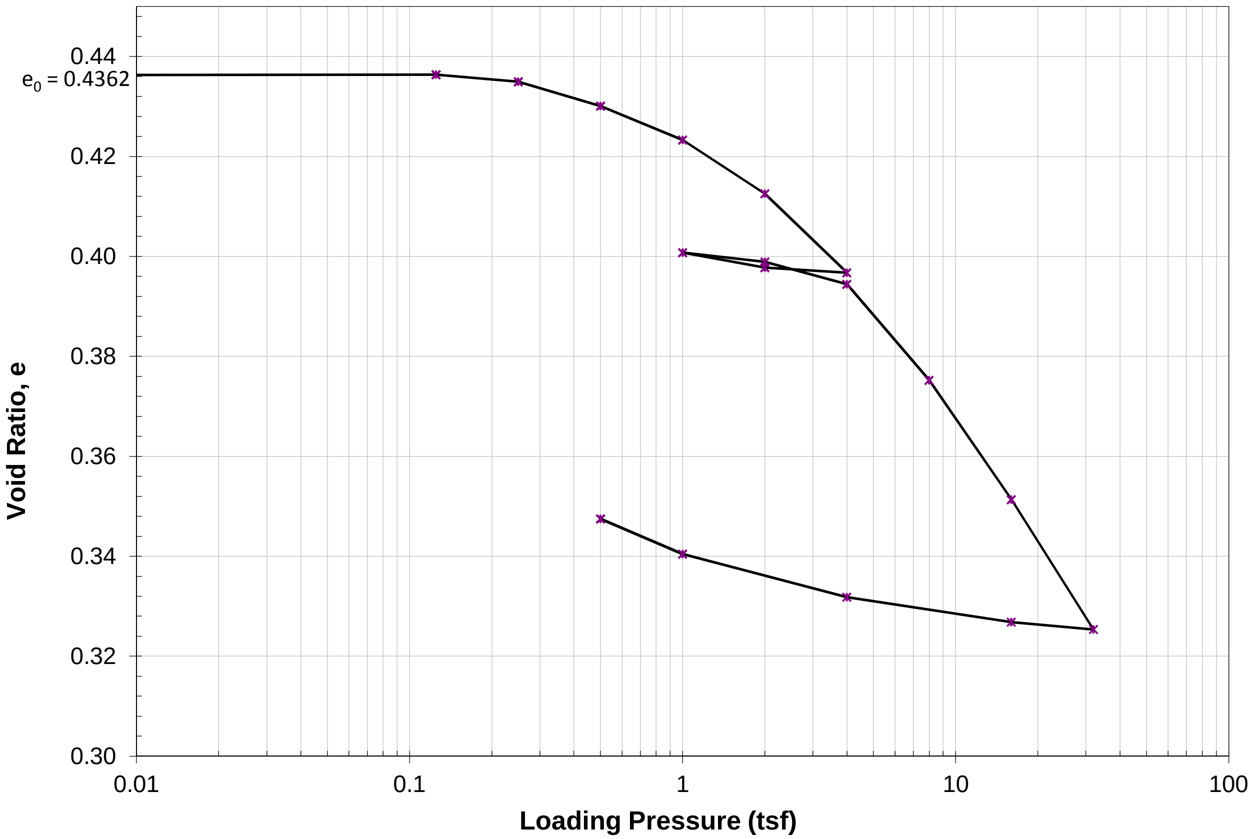


PLATE A-18

CONSOLIDATION TEST RESULTS



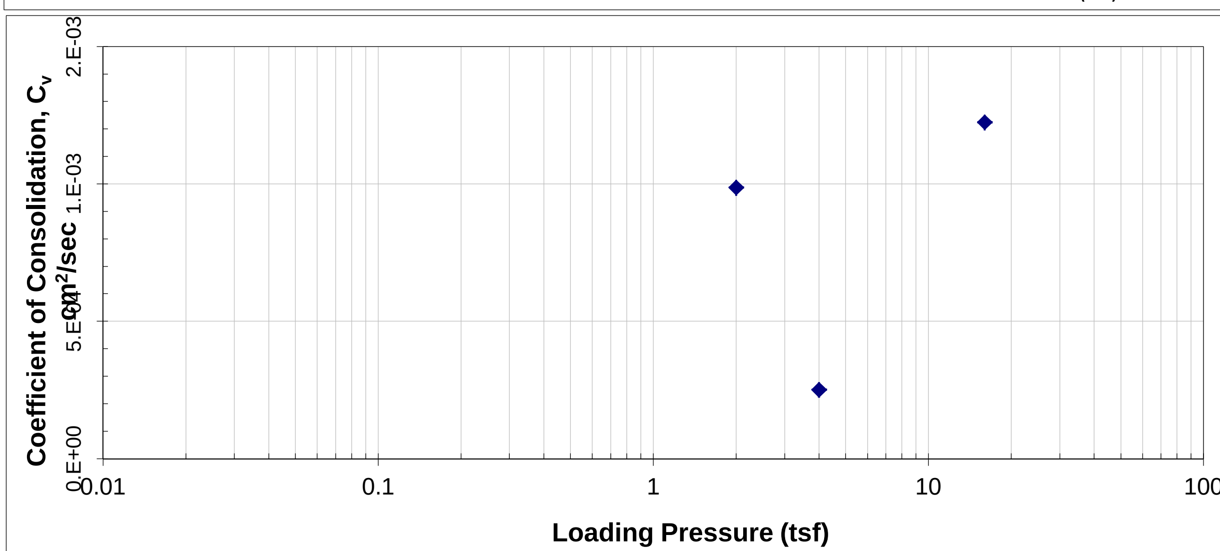
Project No.: G128-12 — Project: Northwest WWTP Improvements

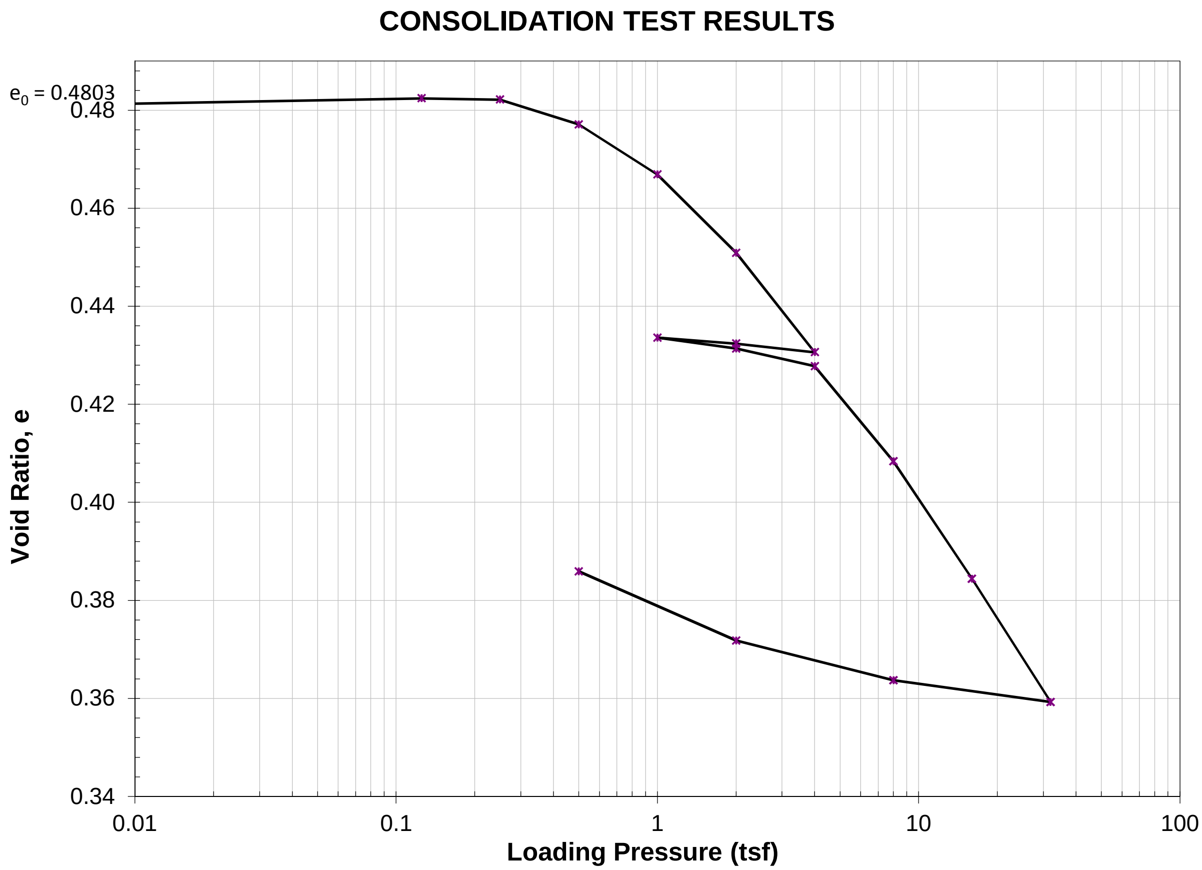
Sample ID: B-4, 14 to 16 feet

Sample Description: Fill: brown and tan Sandy Lean Clay (CL) — Dry Unit Weight (γ_d): 115 pcf

Estimated Consolidation Index (Cc): 0.0869 — Estimated Recompression Index (Cr): 0.0080

Estimated OCR: 3.1 — Estimated Preconsolidation Pressure (Pc): 2.8 tsf





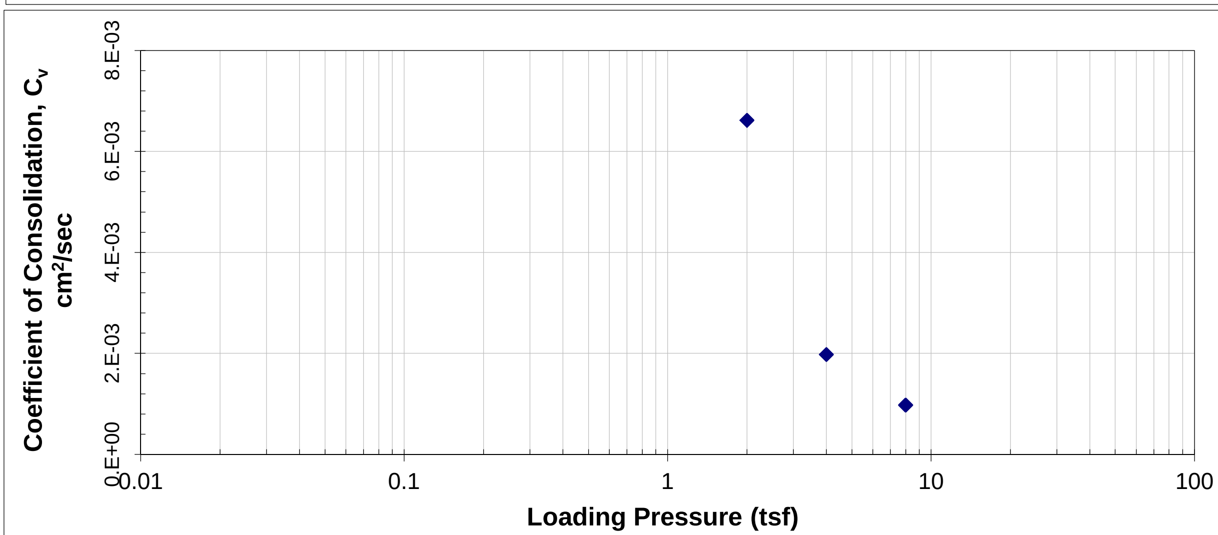
Project No.: G128-12 Project: Northwest WWTP Improvements

Sample ID: B-8, 8 to 10 feet

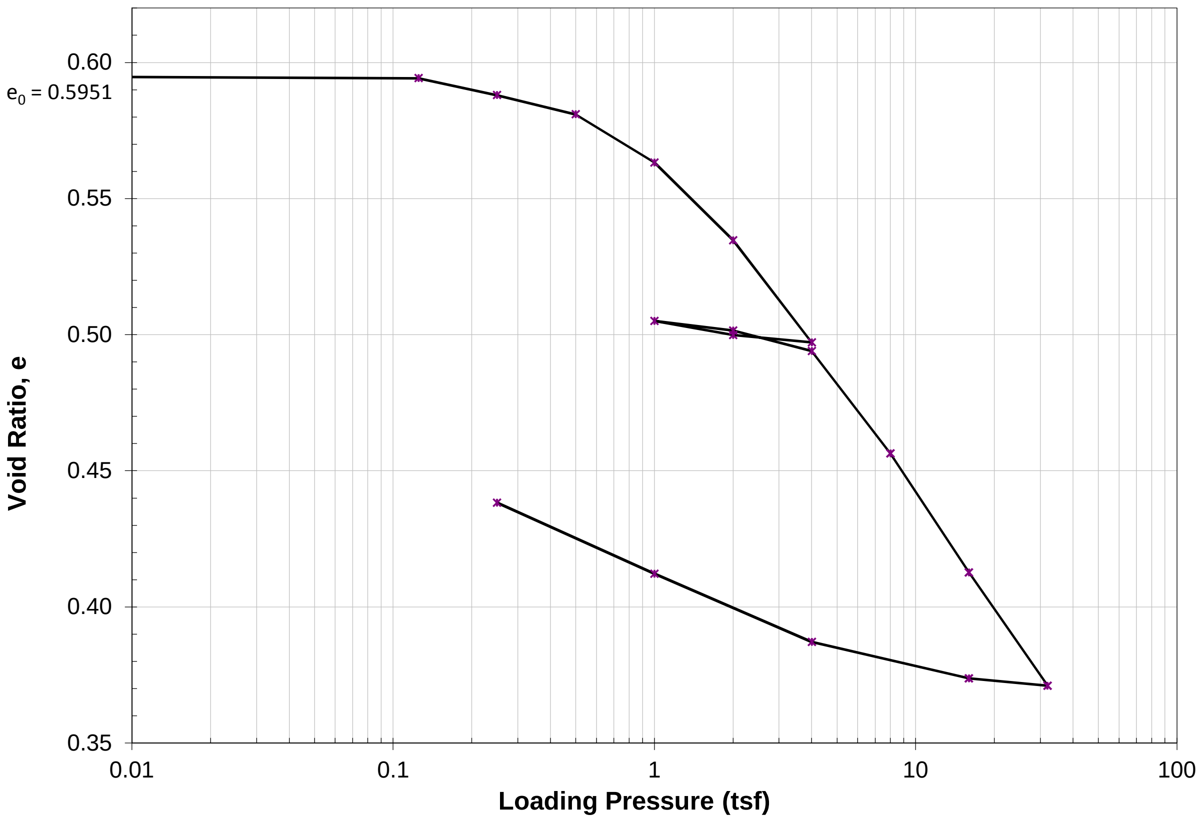
Sample Description: Fill: brown and tan Clayey Sand (SC) Dry Unit Weight (γ_d): 110 pcf

Estimated Consolidation Index (Cc): 0.0830 Estimated Recompression Index (Cr): 0.0089

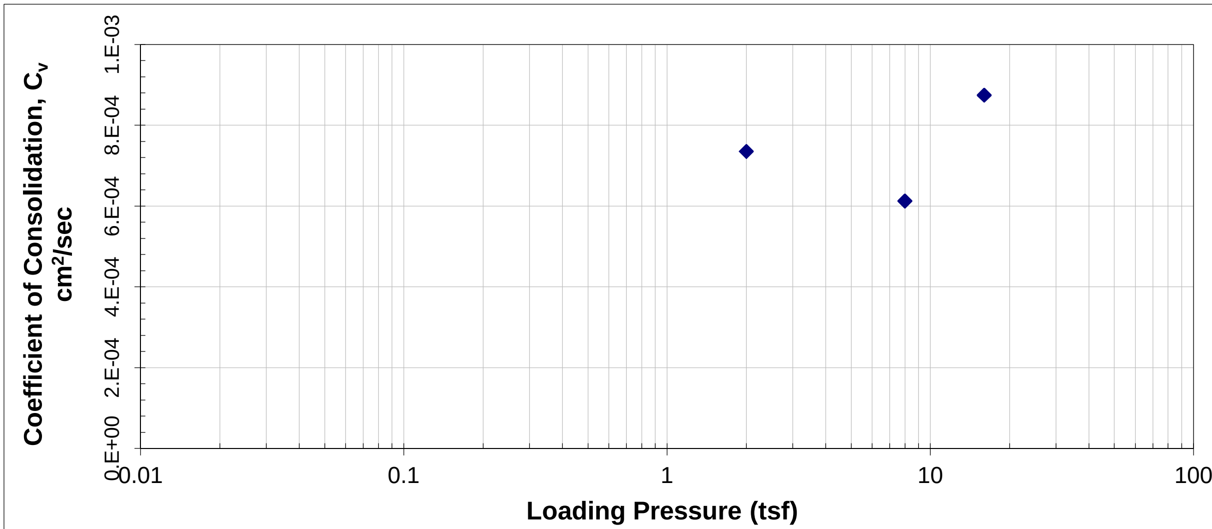
Estimated OCR: 2.9 Estimated Preconsolidation Pressure (Pc): 1.4 tsf



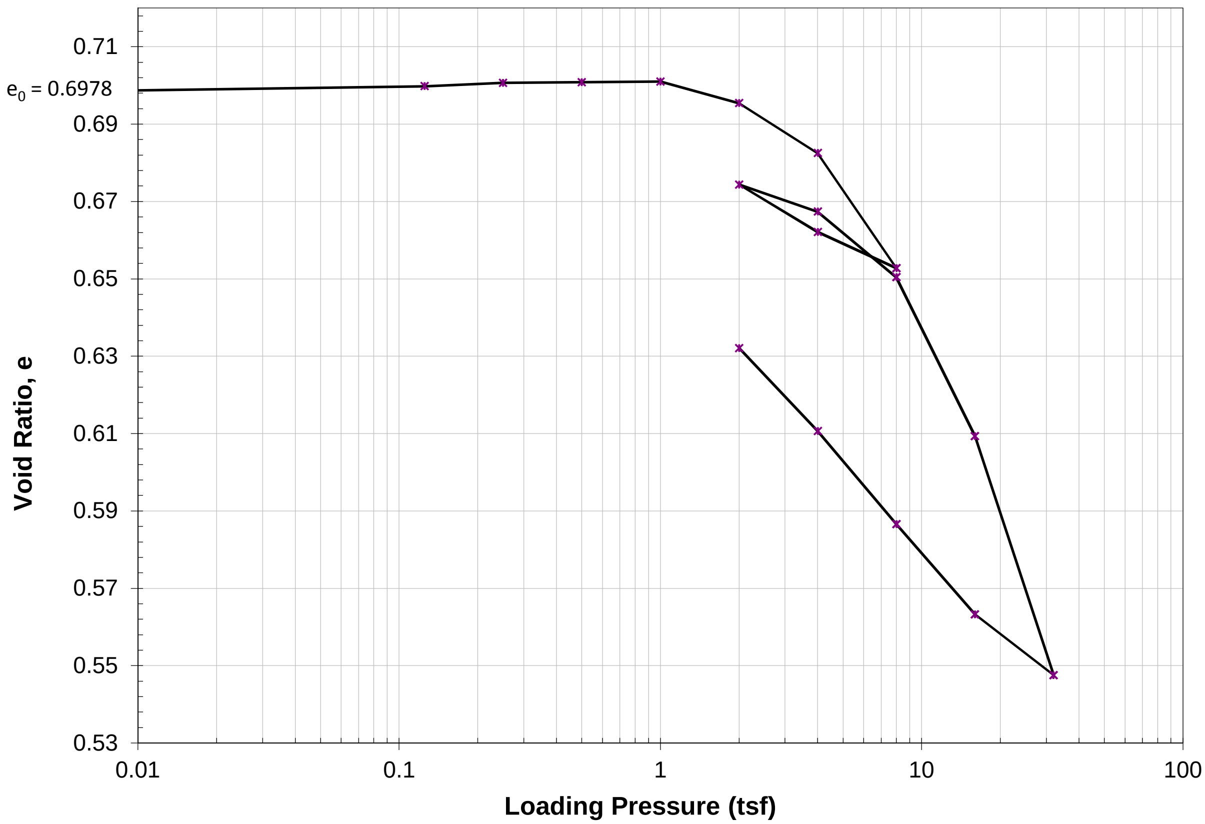
CONSOLIDATION TEST RESULTS



Project No.: G128-12 Project: Northwest WWTP Improvements
Sample ID: B-9, 16 to 18 feet
Sample Description: Fill: brown and tan Lean Clay (CL) Dry Unit Weight (γ_d): 107 pcf
Estimated Consolidation Index (Cc): 0.1384 Estimated Recompression Index (Cr): 0.0148
Estimated OCR: 1.5 Estimated Preconsolidation Pressure (Pc): 1.1 tsf



CONSOLIDATION TEST RESULTS



Project No.: G128-12

Project: Northwest WWTP Improvements

Sample ID: B-9, 43 to 45 feet

Sample Description: Red Fat Clay (CH)

Dry Unit Weight (γ_d): 99 pcf

Estimated Consolidation Index (Cc): 0.2025

Estimated Recompression Index (Cr): 0.0373

Estimated OCR: 4.5

Estimated Preconsolidation Pressure (Pc): 6.9 tsf

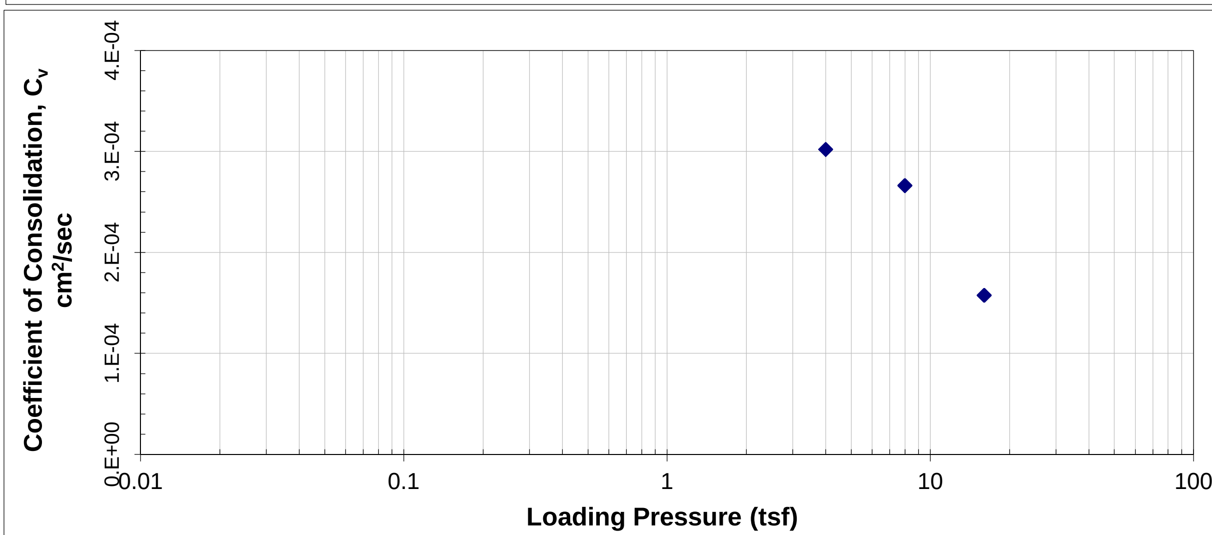


PLATE A-22

ESTIMATED TIME RATE OF CONSOLIDATION SETTLEMENT IN CLAYS
(Mat Placed at 6-ft , Assuming 12-month Construction Period Starting at Time 0)

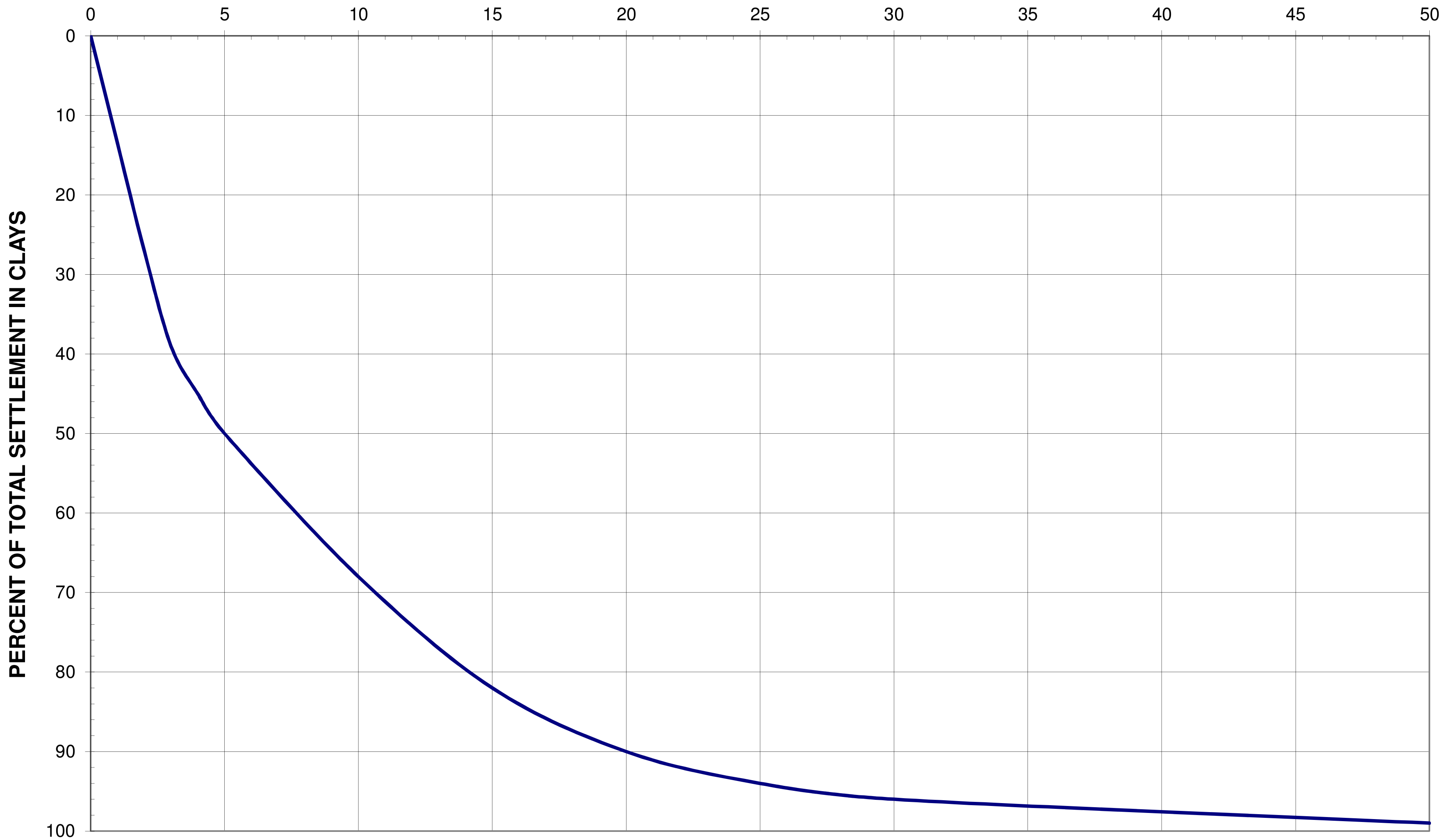


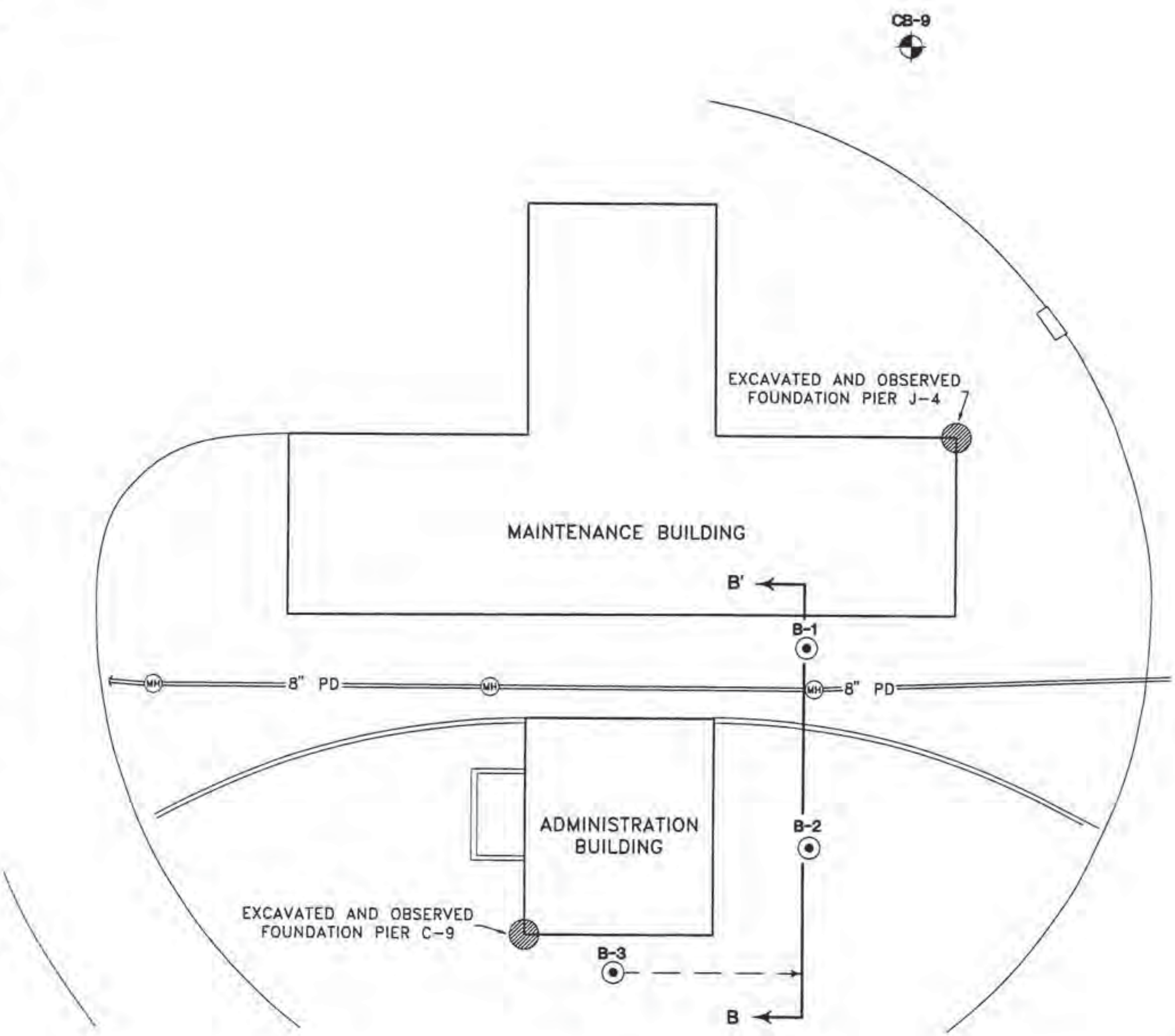
PLATE A-23

APPENDIX B

Plates B-1 to B-3	Bernard Johnson Incorporated/Fugro-McClelland (Southwest) Inc. Geotechnical Evaluation, “Sinkhole and Building Distress at Northwest Wastewater Treatment Plant”, dated December 1993, Plan of Borings, Log of Boring No. 1, Subsurface Profile ‘B-B’
Plate B-4 to B-6	KIT Professionals, Inc., “Northwest WWTP Improvements”, Blower Building Elevations, Admin Building Elevations, Chemical Building Elevations
Plate B-7	Malcolm Pirnie, “Chemical Building Structural Foundation Plan & Sections”, dated March 1988, with modifications by KIT Professionals
Plate B-8	S. Sekhar Ambadapudi, P.E., “City of Houston - NW WWTP Improvements - Existing structural loadings on foundations”, Email to Shou Ting Hu, P.E., dated August 28, 2012

Report No. 0401-2769

DRAFT



NOTE:

SEE PLATE 19 FOR SUBSURFACE PROFILE B-B'.

LEGEND:

- BORING LOCATIONS, FUGRO-MCCLELLAND, OCTOBER 16 & 18, 1993.
- BORING LOCATION, PREVIOUS STUDY BY OTHERS, AUGUST 30, 1985.
- EXCAVATED AND OBSERVED FOUNDATION PIERS J-4 AND C-9.
- DEEP 8-IN. DIAMETER PIPE DRAIN AND ACCESS MANHOLES.

PLAN OF BORINGS

0 20 40 FEET

DRAFT

Report No. 0401-2769

Water First Noticed: See Text
Completion Depth: 37.0' Date: October 17, 1993
Type: Dry Auger to 15'; Wet Rotary below 15'
Logger: T. Mireles

Depth to Water: See Text
Caved Depth: Not Applicable
Date: Not Applicable
Backfill: Bentonite Granules

Location: See Plate 9
Surf El. 88.8'

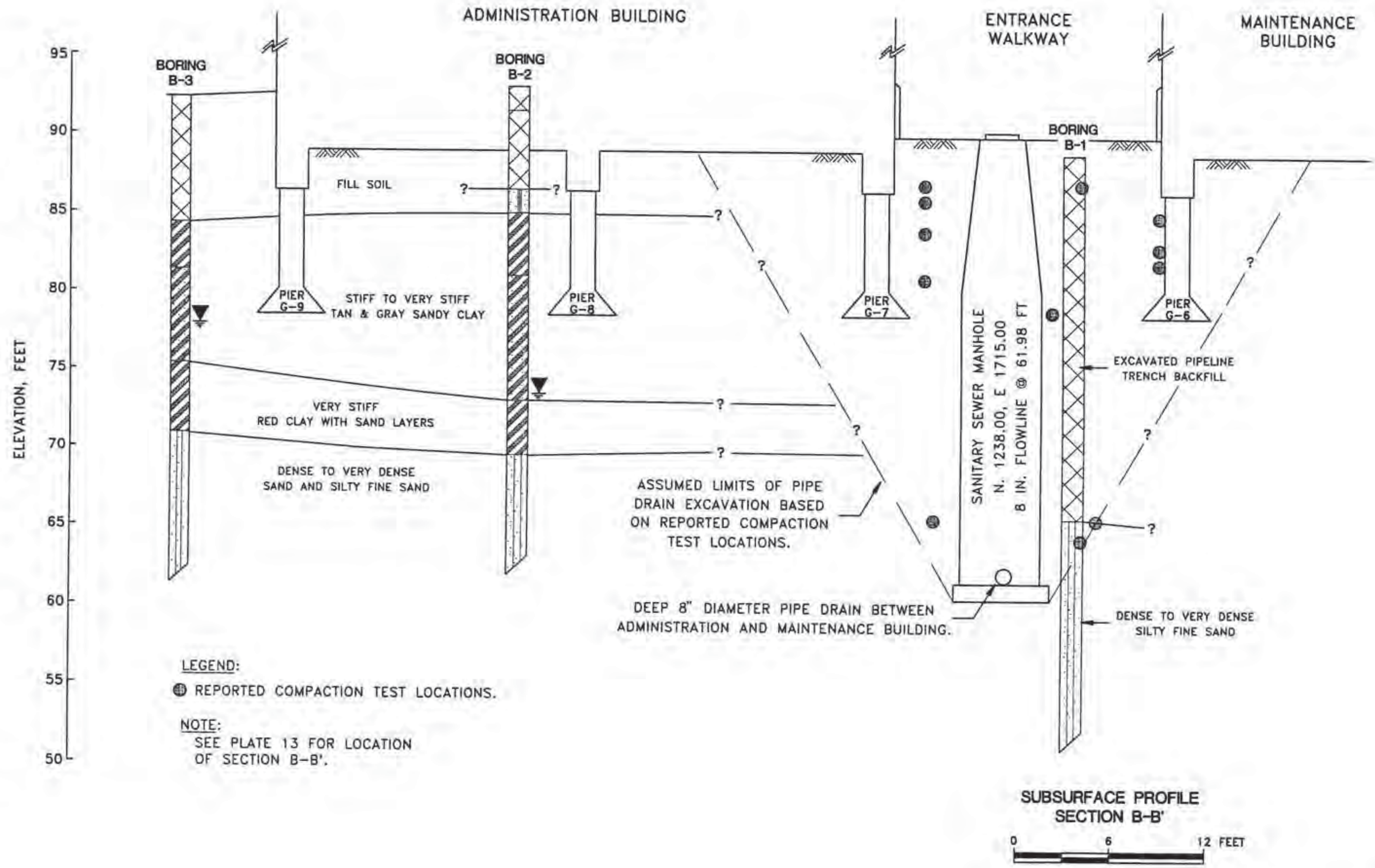
STRATUM DESCRIPTION	LAYER ELEV./DEPTH	BLOWS PER FOOT
CONCRETE		
VOID	0.3	
FILL: SAND, fine, leveling	0.7	
FILL: SANDY CLAY, very soft to firm, gray and tan, with sand pockets	0.8	
SILTY SAND, medium dense to very dense, light gray, fine grained	65.3 / 23.5	
- tan, with clay seams below 28'		24 (30') ; 50/6" (35')
	51.8 / 37.0	

WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	PASSING NO. 200 SIEVE, %	UNIT DRY WEIGHT, PCF	SHEAR STRENGTH, KSF
						0.6 P
24						
						0.6 P
20						
						0.5 P
						0.3 P
23					102	0.3 P
						0.3 Q
20	33	11	22		108	0.7 P
						0.8 Q
23						
22					107	0.6 P
						0.7 Q
						0.6 P

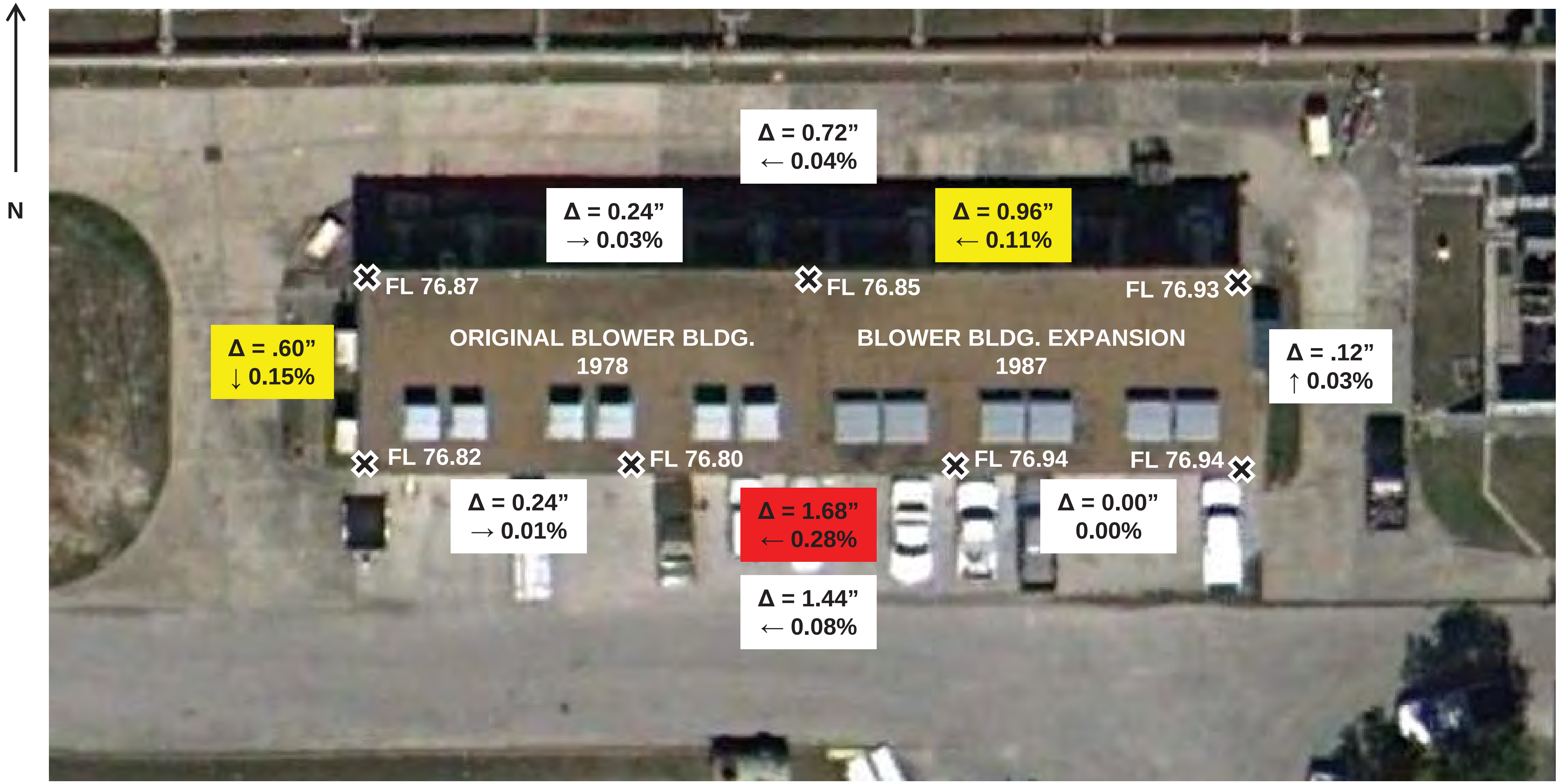
DEPTH, FT: 5, 10, 15, 20, 25, 30, 35, 40

LOG OF BORING NO. 1
CITY OF HOUSTON
NORTHWEST WWTP
HOUSTON, TEXAS

DRAFT



SUBSURFACE PROFILE
SECTION B-B'



LEGEND

✖ SURVEY POINT, APPROXIMATE
→ SLOPE DIRECTION
Δ ELEVATION CHANGE

SETTLEMENT SLOPE < 0.10 %

.10% < SETTLEMENT SLOPE < 0.20%

SETTLEMENT SLOPE > 0.20%

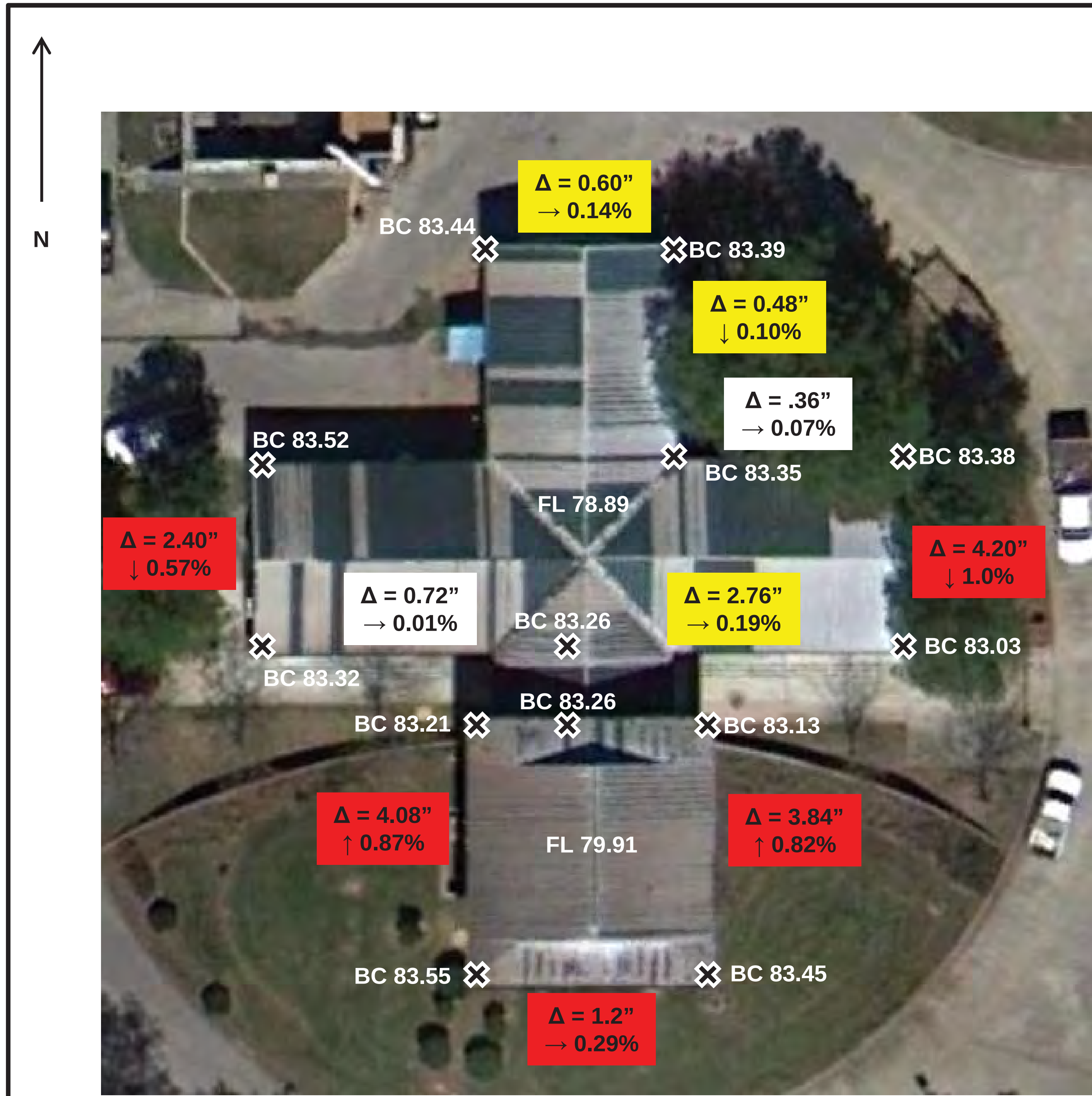
ABBREVIATIONS

BC	BUILDING CORNER
FL	FLOOR
TOW	TOP OF WALL

KIT Professionals, Inc.
Engineers • Planners • Construction Managers
2825 Wilcrest Drive, Suite 600, Houston, Texas 77042
Phone: (713) 783-8700 • Fax: (713) 783-8747

Northwest WWTP Improvements
Exhibit #.#
Blower Bldg. Elevations
WBS No. R-000265-0095-3

PLATE B-4



LEGEND

✖ SURVEY POINT, APPROXIMATE
→ SLOPE DIRECTION
Δ ELEVATION CHANGE

SETTLEMENT SLOPE < 0.10 %
.10% < SETTLEMENT SLOPE < 0.20%
SETTLEMENT SLOPE > 0.20%

ABBREVIATIONS

BC	BUILDING CORNER
FL	FLOOR
TOW	TOP OF WALL

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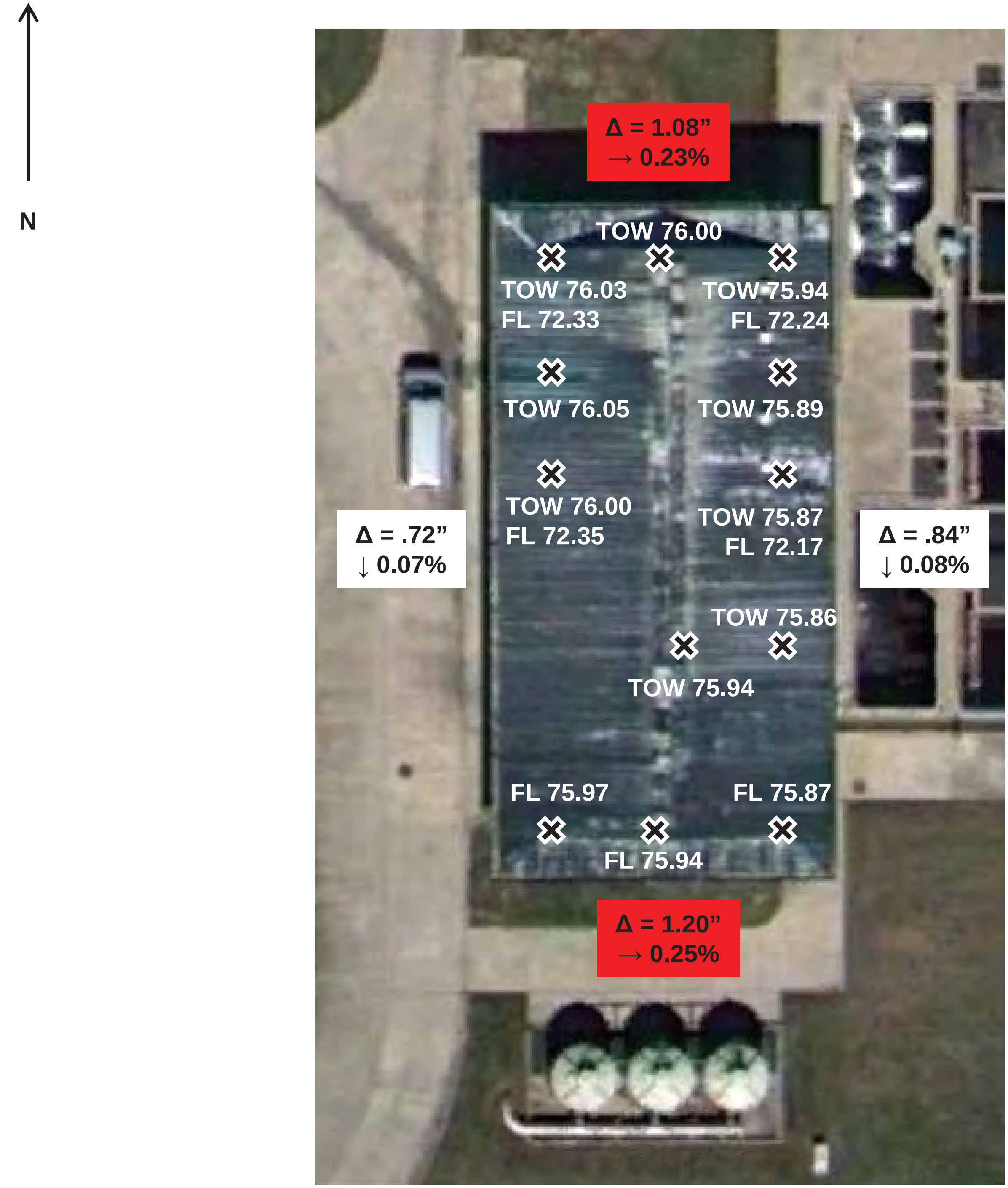
Phone: (713) 783-8700 • Fax: (713) 783-8747

Northwest WWTP Improvements
Exhibit #.#
Admin Bldg. Elevations
WBS No. R-000265-0095-3

PLATE B-5



LEGEND

✕ SURVEY POINT, APPROXIMATE
→ SLOPE DIRECTION
Δ ELEVATION CHANGE

SETTLEMENT SLOPE < 0.10 %
.10% < SETTLEMENT SLOPE < 0.20%
SETTLEMENT SLOPE > 0.20%

ABBREVIATIONS

BC BUILDING CORNER
FL FLOOR
TOW TOP OF WALL

KIT Professionals, Inc.
Engineers • Planners • Construction Managers
2825 Wilcrest Drive, Suite 600, Houston, Texas 77042
Phone: (713) 783-8700 • Fax: (713) 783-8747

Northwest WWTP Improvements
Exhibit #.#
Chemical Bldg. Elevations
WBS No. R-000265-0095-3

PLATE B-6

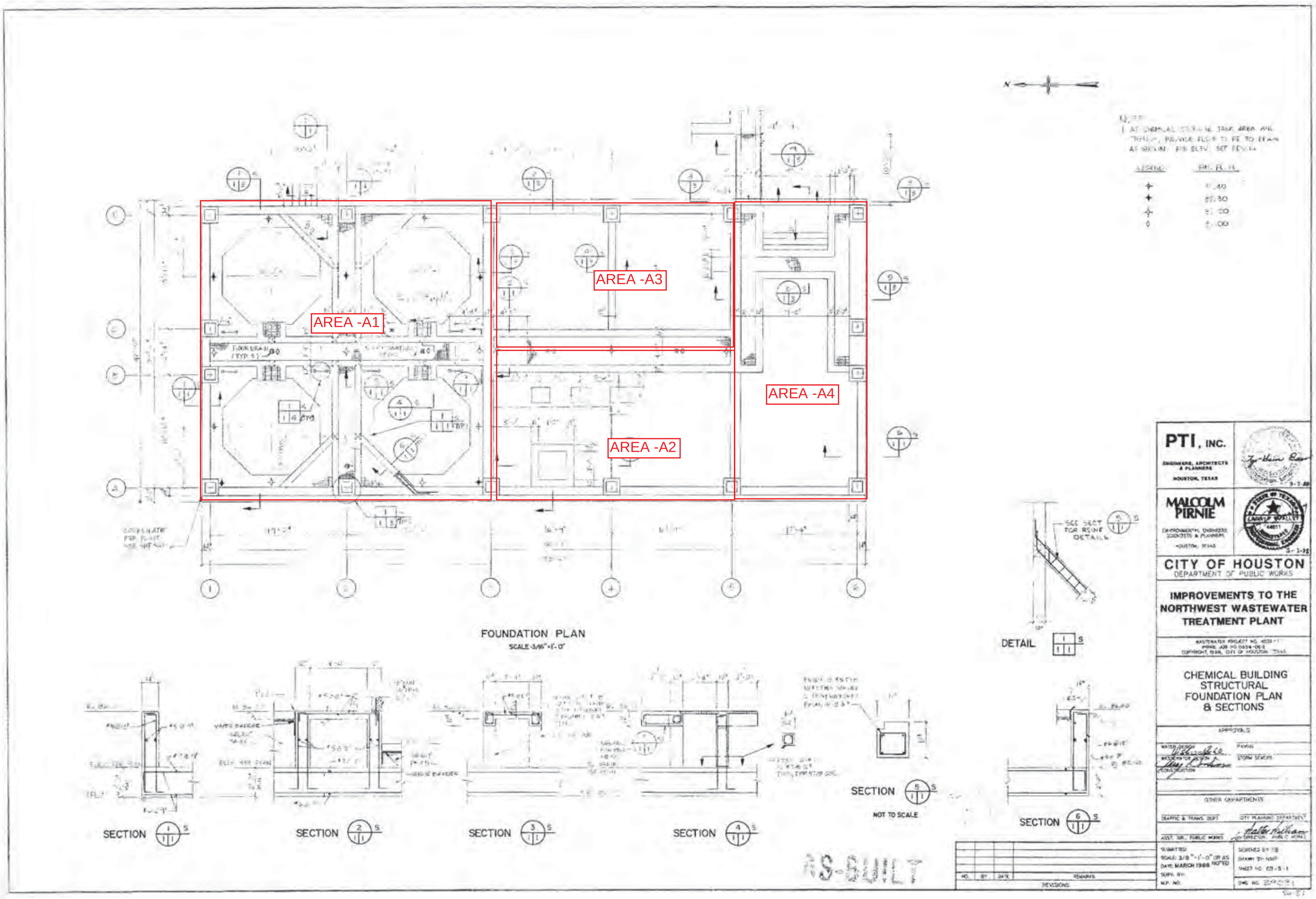

AREA -A1
AREA -A2
AREA -A3
AREA -A4
FOUNDATION PLAN
SCALE 3/16"=1'-0"
DETAIL
SECTION
SECTION
SECTION
SECTION
SECTION
NOT TO SCALE
SECTION
PTI, INC.
MALCOLM PIRNIE
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS
IMPROVEMENTS TO THE NORTHWEST WASTEWATER TREATMENT PLANT
CHEMICAL BUILDING STRUCTURAL FOUNDATION PLAN & SECTIONS
APPROVALS
OTHER DEPARTMENTS
REVISIONS
AS-BUILT

PLATE B-7

Wilber Wang

From: Sekhar Ambadapudi <SAMBADAPUDI@kitprofs.com>
Sent: Tuesday, August 28, 2012 2:51 PM
To: Shou Ting Hu; Sheldon M. Buck
Cc: 'Wilber Wang'
Subject: RE: City of Houston - NW WWTP Improvements - Existing structural loadings on foundations

Shou,

You are right. We provided you with the column 20"/60" which is getting the maximum load as DL=55 kips and LL=10 kips.

The answers for your questions below:

1) Column H-5A - shaft/bell diameters: 12"/30" : DL =22 KIPS and LL=8 KIPS
2) Column J-5A - shaft/bell diameters: 18"/54" : DL =49 KIPS and LL=6 KIPS

Give me a call or email me if you have any questions.

Thanks,

S. Sekhar Ambadapudi, PE., CFM
Project Manager

KIT Professionals, Inc.
2825 Wilcrest Drive, Suite 600, Houston TX 77042
Ph: (713) 783-8700, Ext 260 | Fax: (713)783-8747 | Cell: (281)235-9202
sambadapudi@kitprofs.com

From: Shou Ting Hu [mailto:sthu@avilesengineering.com]
Sent: Friday, August 24, 2012 6:23 PM
To: Sekhar Ambadapudi; Sheldon M. Buck
Cc: 'Wilber Wang'
Subject: RE: City of Houston - NW WWTP Improvements - Existing structural loadings on foundations

Sekhar,

Could you provide me the column loads at the following locations (referenced Drawings "Control and Maintenance Building Structural Foundation Plan", Sheet CM-S-1):

1) Column H-5A (I use 5A to represent the line between lines 4 and 6, same as below), shaft/bell diameters: 12"/30"; and
2) Column J-5A, shaft/bell diameters: 18"/54".

I am assuming that the typical loads DL = 55 kips, and LL = 10 kips in Item 3 of your email below are for footing size of 20"/60", correct?

Thanks,

Shou Ting Hu, P.E.
Aviles Engineering Corp.
TBPE Firm Registration No. 42
5790 Windfern
Houston, TX 77041
Phone: 713-895-7645
Fax: 713-895-7943
E-mail: sthu@avilesengineering.com

From: Sekhar Ambadapudi [mailto:SAMBADAPUDI@kitprofs.com]
Sent: Monday, August 13, 2012 11:15 AM
To: Shou Ting Hu; Sheldon M. Buck
Cc: 'Wilber Wang'
Subject: RE: City of Houston - NW WWTP Improvements - Existing structural loadings on foundations

Shou,

Please find below the requested information:

The existing structural loadings on foundations for several buildings are as follows:

1) Chemical building (Areas are delineated per the attached sketch) – footing pressures (unfactored live and dead loads) for the mat :
   Area – A1 = DEAD LOAD = 1.3 KIPS/SF (This area accounts for Bleach Tank loadings)
   LIVE LOAD = 0.20 KIPS/SF

   Area—A2:

   DEAD LOAD = 0.80 KIP/SF
   LIVE LOAD = 0.20 KIP/SF

   Area—A3 :

   DEAD LOAD = 0.80 KIP/SF
   LIVE LOAD = 0.20 KIP/SF

   Area—A4 :

   DEAD LOAD = 0.30 KIP/SF
   LIVE LOAD = 0.20 KIP/SF

2) Blower building:
   Typical unfactored live and dead loads on columns:

   DEAD LOAD = 163 KIPS
   LIVE LOAD = 12 KIPS

3) Control and Maintenance building:
Typical unfactored live and dead loads on columns:

DEAD LOAD = 55 KIPS
LIVE LOAD = 10 KIPS

4) Administration building
Typical unfactored live and dead loads on columns:

DEAD LOAD = 65 KIPS
LIVE LOAD = 10 KIPS

Please let me know if you have any questions.

Thanks,

S. Sekhar Ambadapudi, PE., CFM
Project Manager

KIT Professionals, Inc.
2825 Wilcrest Drive, Suite 600, Houston TX 77042
Ph: (713) 783-8700, Ext 260 | Fax: (713)783-8747 | Cell: (281)235-9202
sambadapudi@kitprofs.com

From: Shou Ting Hu [mailto:sthu@avilesengineering.com]
Sent: Monday, August 13, 2012 8:21 AM
To: Sheldon M. Buck
Cc: Sekhar Ambadapudi; 'Wilber Wang'
Subject: RE: City of Houston - NW WWTP Improvements - Existing structural loadings on foundations

Thanks Sheldon.

Sekhar, do you have live load and dead load (you provided the total loads in your e-mail below) information for the buildings available?

Thanks,

Shou Ting Hu, P.E.
Principal
Aviles Engineering Corp.
TBPE Firm Registration No. 42
5790 Windfern
Houston, TX 77041
Phone: 713-895-7645
Fax: 713-895-7943
E-mail: sthu@avilesengineering.com

From: Sheldon M. Buck [mailto:sbuck@kitprofs.com]
Sent: Friday, August 10, 2012 6:51 PM
To: Shou Ting Hu
Cc: Sekhar Ambadapudi
Subject: FW: City of Houston - NW WWTP Improvements - Existing structural loadings on foundations

Shou,

The building loads for the Northwest WWTP are below. Please let Sekhar know if you have any questions.

Sheldon M. Buck, P.E.
Senior Project Manager

KIT Professionals, Inc.
2825 Wilcrest Drive, Suite 600, Houston TX 77042
Ph: (713) 783-8700, Ext 252 | Fax: (713) 783-8747 | Cell: (281) 450-7698
sbuck@kitprofs.com

From: Sekhar Ambadapudi
Sent: Friday, August 10, 2012 12:20 PM
To: Sheldon M. Buck
Cc: Ankit Desai
Subject: City of Houston - NW WWTP Improvements - Existing structural loadings on foundations

Sheldon,

The existing structural loadings on foundations for several buildings are as follows:

1) Chemical building (Areas are delineated per the attached sketch) – footing pressures (unfactored live and dead loads) for the mat :
   Area – A1 = 1.5 KIPS/SF (This area accounts for Bleach Tank loadings)
   Area—A2 = 1.0 KIP/SF
   Area—A3 = 1.0 KIP/SF
   Area—A4 = 0.50 KIP/SF

2) Blower building
   Typical unfactored live and dead loads on columns = 175 KIPS

3) Control and Maintenance building
   Typical unfactored live and dead loads on columns = 65 KIPS

4) Administration building
   Typical unfactored live and dead loads on columns = 75 KIPS

Please let me know if you have any questions.

Thanks,

S. Sekhar Ambadapudi, PE., CFM
Project Manager

KIT Professionals, Inc.
2825 Wilcrest Drive, Suite 600, Houston TX 77042
Ph: (713) 783-8700, Ext 260 | Fax: (713)783-8747 | Cell: (281)235-9202
sambadapudi@kitprofs.com

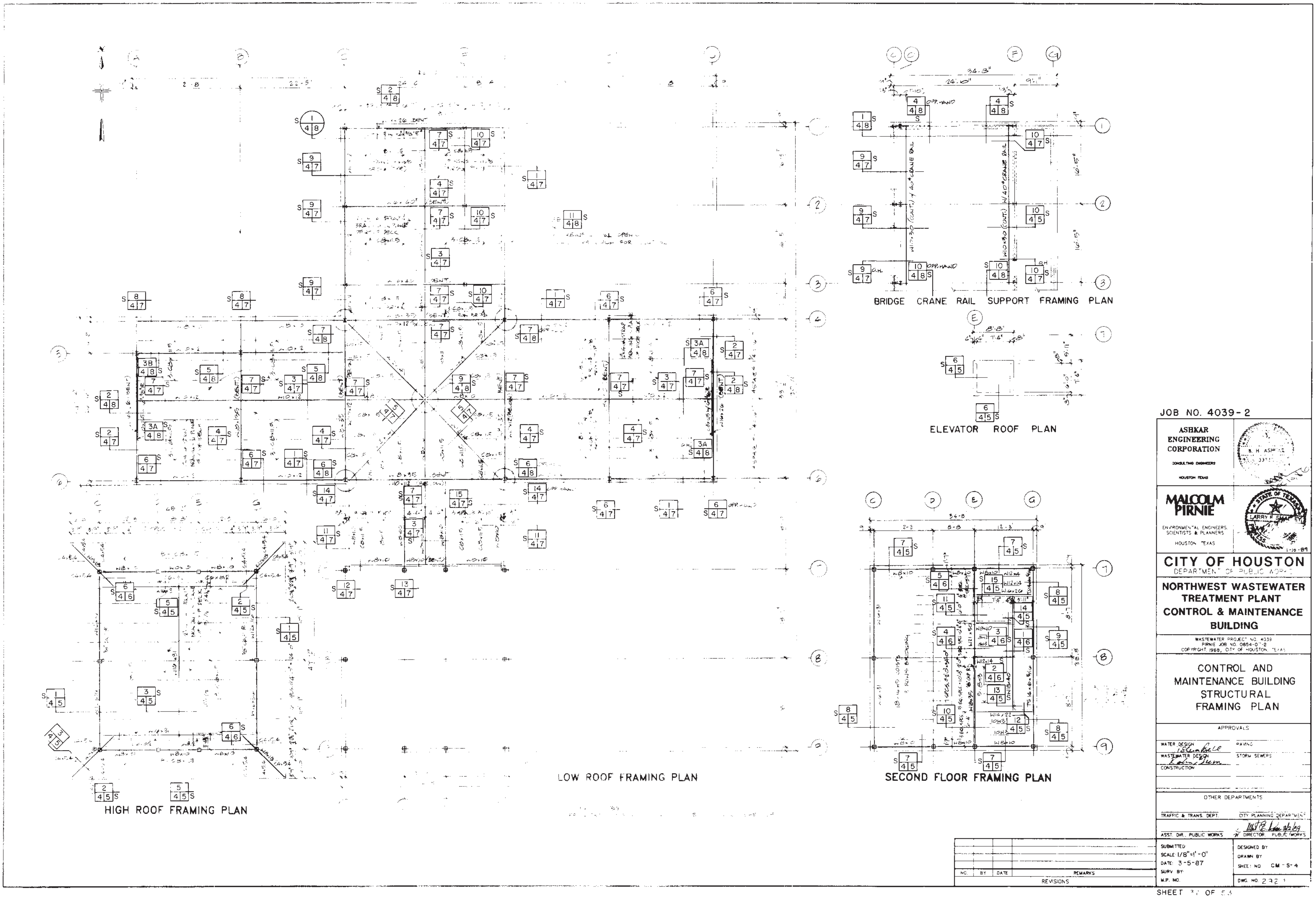

HIGH ROOF FRAMING PLAN
LOW ROOF FRAMING PLAN
BRIDGE CRANE RAIL SUPPORT FRAMING PLAN
ELEVATOR ROOF PLAN
SECOND FLOOR FRAMING PLAN
JOB NO. 4039-2
ASHKAR ENGINEERING CORPORATION
MALCOLM PIRNIE
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS
HOUSTON TEXAS
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS
NORTHWEST WASTEWATER TREATMENT PLANT
CONTROL & MAINTENANCE BUILDING
CONTROL AND MAINTENANCE BUILDING STRUCTURAL FRAMING PLAN
APPROVALS
OTHER DEPARTMENTS
SCALE 1/8"=1'-0"
DATE 3-5-87
SHEET NO. CM-S-4
REVISIONS

PLATE B-9